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NUMBER 44

MACHINE BLACKSMITHING

By JAMES CRAN

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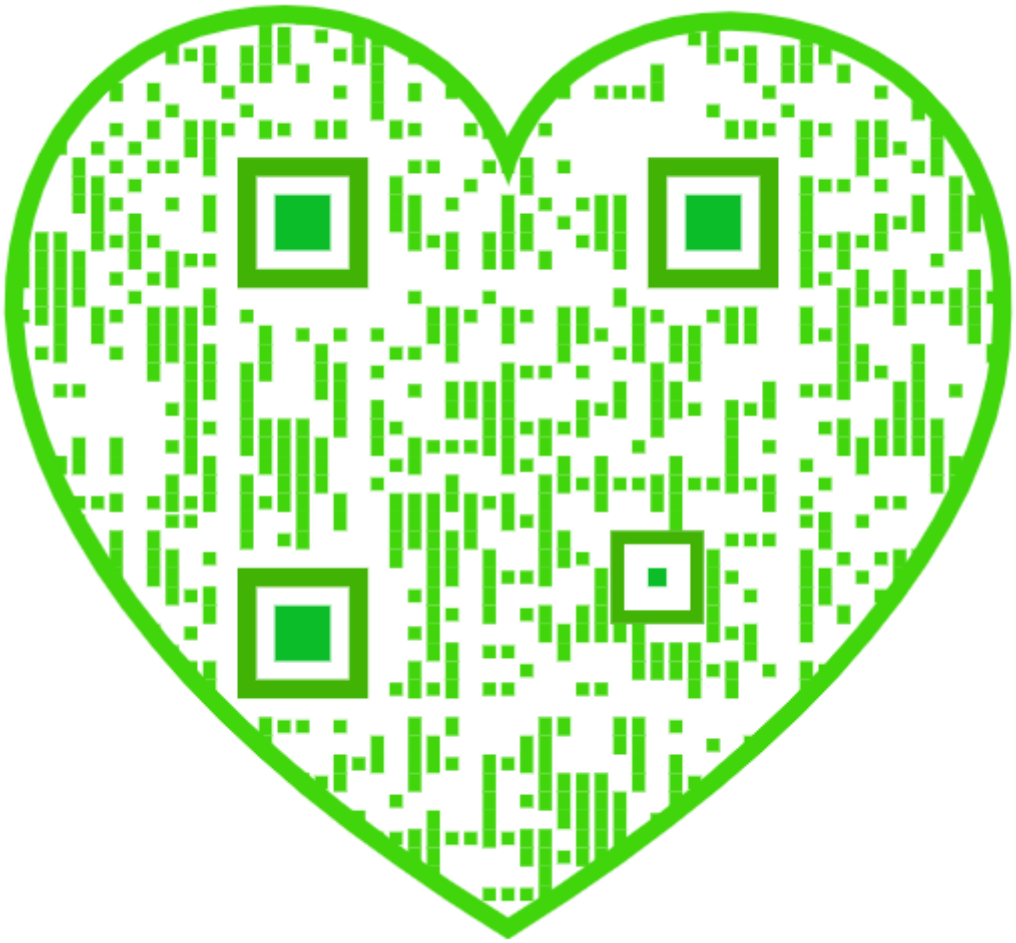

CHAPTER I

SYSTEM IN THE BLACKSMITH SHOP

It is not necessary that a system for the blacksmith shop be of the kind usually known as red tape, which often takes more time to handle than the time it saves; but a simple method of keeping track of work, tools, and material will save time and expense.

To begin with, the blacksmith shop ought to be large enough to provide a place for everything in the shape of tools and equipment, and permit everything to be in its place. Forges should be numbered with figures of size and color which can be easily seen from any part of the shop. The forges should be referred to by their numbers, instead of "so-and-so's" forge. This would insure work being taken to the place it was meant for. With each forge there ought to be a tool bench of size and design which would accommodate one full set of blacksmith's tools such are used at the anvil. Each tool should be marked with its size and the number of the forge to which it belongs, so that each blacksmith will know the tools which form part of the set he is supposed to use, even if they should in any way get mixed up with others. To insure keeping a full set at each forge, it would be well to give each man a list of the tools belonging to the forge at which he is expected to work, with the understanding that he will be held responsible for all tools not worn out or accidentally broken. Any tool worn out or broken should be reported to the man in charge, so that they could be replaced as soon as possible. Having a full equipment at each forge would be a decided advantage to new men starting in to work, because, as anyone who has ever been employed in a blacksmith shop knows, as soon as a blacksmith leaves the shop in which he has been working, he is no sooner gone than there is a raid upon the tools he used, and it usually takes but a short time to have them exchanged for the poorest tools in the shop, or, perhaps, just removed without any attempt at replacing. When a new man comes along, he is heavily handicapped, having the worst tools in the place to work with, and it sometimes takes weeks before he has a chance of showing what he can do.

It would be well, in arranging forges, to place them so that light work could be done at one end of the shop, medium work in the center, and heavy work at the other end, so that trip- or steam-hammers could be installed in the most convenient places according to their capacities. Every shop ought to have one or more sets of hammer tools, such as spring swages, spring fullers, bolsters, V-blocks, drifts, hacks, and breaking-down tools, which could be classed as general tools and used at any hammer, and kept on a rack where they would be most convenient. Special and larger tools than those forming sets

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for forges could be given out on the check system, which is common in most manufacturing plants where tools are given out from the tool-room.

To keep track of stock, it would be well to have each kind or grade marked on the end of the bars with different colors. Thus wrought iron may be marked red; Norway iron, blue; machinery steel, white; and so on until all the different grades are marked, care being taken to cut from the end not painted. When a blacksmith starts on a new piece of work he should be furnished with a card for stock to be used, along with his time card. Stock cards should be printed forms to be filled in and signed by the various hands they would pass through. The following outline would cover the most essential points: Date of issue, order number, workman's number, name of pieces to be made, number of pieces to be made, grade of stock to be used, size of stock to be used, amount of stock issued, amount of stock returned, amount of stock used, and date when work is completed. The card should be signed by the man in charge of the stock and the foreman of the shop, before being sent to the stock clerk.

Piece work is preferable to day work when the number of pieces to be made is such that it can be done to advantage, as it insures the best men getting the most compensation, especially if there is no limit set to the amount they may earn. This is a very important point. It is by no means an uncommon occurrence for a piece of work to be done the same way, and remain at the same price for years until some one comes along who uses a little more common sense than the average man. He sees a way of doing it to save time, and will perhaps turn out double the amount of work as compared with what has been done in the same time before. The result is that he earns on piece work 100 per cent more than the other men have earned. He may be paid for the first lot without any comment being made, but by the time the next lot is to be made, more than likely the price is cut in two, and another man gets the job, which is nothing but taking an unfair advantage of a good workman, and does not encourage him to bring out his best ideas. If a man can make two pieces in the time it used to take to make one piece, it means a saving of 100 per cent in fuel. If the manufacturer has a profit on one piece, it is doubled if two pieces are made in the same time as previously one piece, which, if looked at in the proper way, would be an advantage to both employer and employe.

When day work is the rule, it is quite common to have a scale of wages, and all men at the same class of work are paid at the same rate. One man might be capable of doing considerably more work than another, but at the end of the week they both receive the same amount of compensation, which is anything but encouraging for good workmen. To a great extent this is responsible for the blacksmith's present lack of pride in his work, a pride which used to be common amongst the old-time mechanics. On the other hand, some men seem to worry if they think they have done a little more than their pay calls for; but this class of men seldom has much pay to call for.

It is poor system where each piece of work is given out with instructions how each detail has to be done, as it leaves no chance for improvement or for getting the ideas of the workman. It is a foreman's place to help his men when he finds that they need assistance, and give them instructions when necessary.

To keep track of the different kinds of tools for lathes, planers, etc., which are usually forged and marked in the blacksmith shop, it would be well to have the different brands of steel of which they are made numbered instead of being marked with the initial of the brand. Quite often two or more brands have the same initial, and are liable to get mixed. If marked with numbers, there would practically be no limit to different brands which could be handled without confusion. The blacksmith who forges the tools should have a list of the brands of steel used with the numbers representing them, together with the working instruction which the makers of high-speed steel usually send out to their customers. The system here outlined may be added to or changed to suit circumstances. On the whole, it would take but little time to handle, would increase the efficiency of the blacksmith-shop, would save time and worry, and be an advantage to all concerned.

CHAPTER II.

TOOLS FOR THE BLACKSMITH SHOP

Among mechanics, the blacksmith holds a unique position, he being practically the only one who makes his own tools. This he often does without any apparent aim at economy, beauty, or usefulness, if judged by the chunks of steel on the ends of handles to be found in the odd corners of a great many blacksmith shops. It would not be fair to put the whole blame on the blacksmith, as he is usually allowed but very little time either to keep his tools in repair or to make new ones; the result is that if ever blacksmiths' tools have had a high standard of efficiency, they soon depreciate. Too much reliance seems to be put on the old saying: "A good workman can do a good job with any kind of tools." But when it comes to saving time, which is one of the most important points in modern manufacturing, the good workman with good tools comes out ahead.

Tools used by blacksmiths do not have to be so accurate to size, or made with the same precision as those used by machinists or toolmakers. Still, some of the points most essential to doing good work seem to have been overlooked. It would be to the advantage of all concerned to have one smith in every shop do the tool-making. He would soon become an expert, and would make better tools in less time than the smith who makes a tool occasionally. It would also

insure every man employed having equally good tools and equal chances of doing good work. Tools made by a good blacksmith are preferable to those upon the market for several reasons, the principal of which is the poor quality of the material of which the article on the market is made. Besides, the blacksmith's tools on the market are often poorly constructed and are mostly used in small or country shops where there is no steam hammer.

Swages

Tools such as swages are usually made with the impression or hollow part too deep, the corners too sharp, and the face too long for the best results. Swages, being tools used for finishing round or semi-round work at the anvil after it has been drawn nearly to size at steam or trip hammers, should be constructed so that finishing can be done in the best and quickest manner possible. They should be made in pairs consisting of one top and one bottom piece. The depth of the impression ought to be about one-third the diameter of the piece the swages are intended to finish. The edges or lips of the impression should be well backed off, and all corners rounded to prevent cold

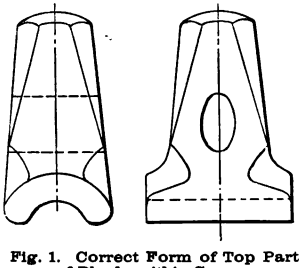
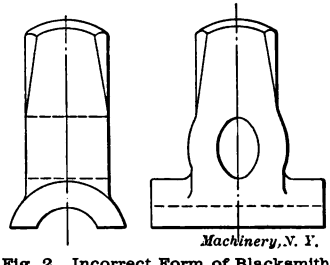


Fig. 1. Correct Form of Top Part of Blacksmith's Swage



Machinery, N. Y.

Fig. 2. Incorrect Form of Blacksmith's Swage, Top Part

shuts and unsightly marks being left upon the work. The swages may be slightly crowned from end to end, which will give them a tendency to draw the stock, should it be a trifle over size, and if the crowning is not overdone, it will tend to leave the work smooth.

The bottom swage should be made to come flush with one side of the anvil, and to reach about half way across it. The swages can then be used for finishing hubs, bosses, and forgings with large heads or arms at right angles to the hub of the work. The bottom swage can also be reversed and used from the other side of the anvil when necessary. Bottom swages should preferably be a little longer on the face than the top swages. For small sizes they might be from 2¼ inches to 2½ inches from end to end of the impression, while the corresponding top swages might be about 1¾ inch. For larger sizes the bottom swage could be from 4 inches to 4½ inches long and the top swage from 2¼ inches to 2½ inches. The number and sizes to constitute a set for one forge would have to be determined by the size and class of work for which the swages would be used. The following list would cover the average range of machine blacksmithing: Top and bottom from 3/16 inch to 1/2 inch, inclusive, advancing by

1/16 inch; from ⅝ inch to 2¼ inches, inclusive, advancing by ⅛ inch; larger sizes up to the limit to advance by ¼ inch. Fig. 1 shows the correct style of top swage, and Fig. 2 an objectionable style. Fig. 3 shows the correct style of bottom swage, and Fig. 4 the incorrect style.

Fullers

The shape and style of fullers is not so important from the fact that there can be no sharp corners to come in contact with the work. Care should be taken to make them in pairs which match each other perfectly. On the bottom fullers it is well to have a large shoulder to rest on the anvil. The shank should be a snug fit to keep it from wabbling.

Flatters

Flatters as a rule are too large and too level on the face for doing good work, and like swages are usually too sharp and square on the corners and edges. More and better work can be done with a flatter 2½ inches square on the face than can be done with one 3 inches square face. When a large level flatter is used, the edges come in contact with the work and leave a mark every time it is struck with

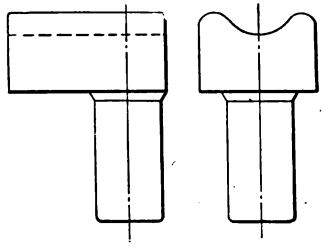
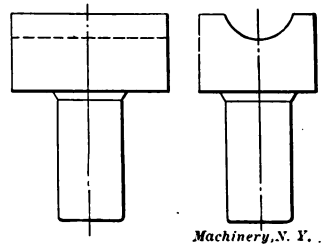


Fig. 3. Correct Form of Bottom Part of Swages



Machinery, N. Y.

Fig. 4. Incorrect Form of Bottom Part of Swages

a sledge. With a small flatter with crowning center and rounded edges a blow with the sledge will have more effect, and it will be almost impossible to leave a mark upon the work. The same principle applies to sets. The style best suited for machine blacksmithing should be from 2¼ inches to 2½ inches long, and from 1⅜ inch to 1½ inch wide on the face. It would be of advantage to have one with the edges well rounded to use around fillets, and one with sharp square edges to finish corners which must be sharp.

Breaking-Down and Miscellaneous Tools

Breaking-down tools should be made with the edge rounded, which will prevent the leaving of a cold shut where the shank joins the body of a forging. Fig. 5 shows the correct style in full lines; the dotted lines show the incorrect style. When square work is being drawn at the steam or trip hammer, it will sometimes become diamond shaped, and it is very hard to work it back to the square form without flattening two of the corners, unless a pair of V swages are used. These ought to have a place in every set of tools, the impression in both top and bottom to be 90 degrees, with the edges well

rounded so that they would have their greatest bearing at the apex of the V. This forces out the other two corners of the work until it is perfectly square, without marking it. Chisels, punches, and gouges must be made to suit the work. The tools previously mentioned, with the exception of chisels, punches, and gouges, could be made of steel of about 0.60 carbon. All tools intended for cutting should be made of steel not less than 0.75 carbon.

Hardening Blacksmiths' Tools

Tools will give better service and satisfaction if hardened on both ends. The writer appreciates the fact that in recommending the hardening of the heads of tools he is laying himself open to criticism, as it is departing from all general rules and practice. Nevertheless, if the head of a tool is propely hardened, the tool will give at least five times more service than a tool with a soft head. In hardening the working end of such tools as swages, flatters, etc., the face, after being heated to the proper temperature, should be cooled in a stream

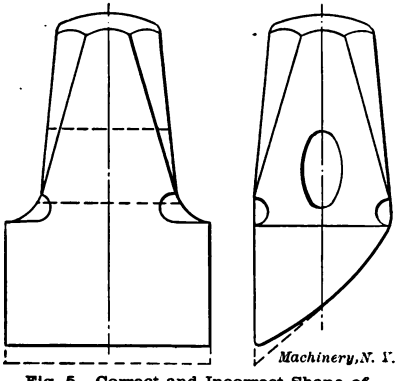


Fig. 5. Correct and Incorrect Shape of Blacksmith's Breaking-Down Tool

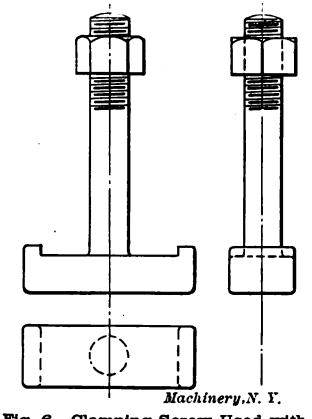


Fig. 6. Clamping Screw Used with Clamp in Fig. 10.

of water rising straight from the bottom of the quenching tub. Care should be taken to hold the tool so that the stream will strike its center, which will insure the center being hard. After the tool is cold enough to carry water on the face, polish, and draw the temper in a hot fire until the edges are a light blue, leaving the center as hard as possible. If hardened in a bath without a stream, the edges are liable to be extremely hard and the center soft.

When hardening the heads of tools, they should be heated to a cherry red about 1 inch of their length, dipped to a depth of about $\frac{5}{8}$ inch in water until fairly cooled, and then the head polished and the temper drawn with back heat until the color just runs out. If much heat is left, dip slightly to check it, and leave the tool to cool off gradually in the air. Heads treated in this manner will neither chip off, nor crack, nor batter down.

Tool Benches

Fig. 7 shows a tool bench which is of a suitable style for the blacksmith's tools. The rack around the top holds tools with handles; the shelf at the bottom accommodates bottom or anvil tools, and the drawer is used to hold such tools as are usually the personal property of the blacksmith, as well as orders, drawings, etc., which ought to be kept clean and out of the range of sparks. A bench of this style made of wood will give good service if the top edges of the rack are covered with light band-iron attached with screws. Every tool ought to have its own place on the bench, swages, fullers, etc., in consecutive arrangement, so that the blacksmith can put his hand on any tool at any time. It takes but very little time to put away a tool immediately

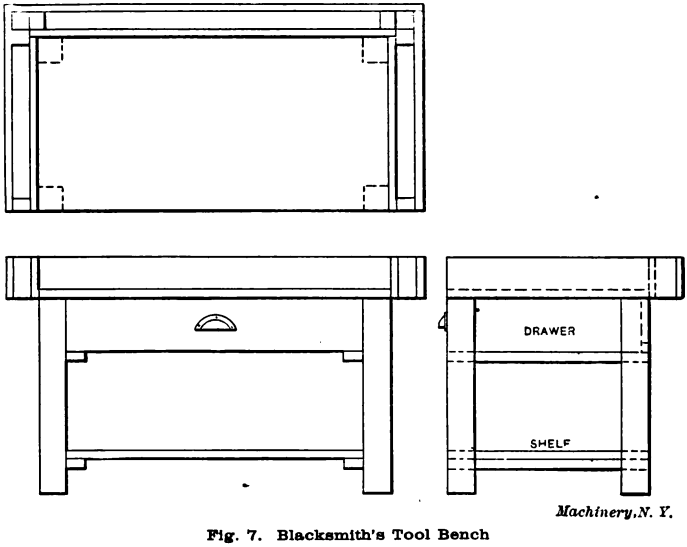


Fig. 7. Blacksmith's Tool Bench

after it has been used. If this is done every time, it will save confusion and lots of expressive language when it is wanted again.

Tongs

The next tools to be considered are tongs. These are by no means the least important of the blacksmith's tools. In order to do good work, it is of the utmost importance to have tongs which will hold the work firmly. In a great many cases tongs are poorly proportioned. For light work they are too heavy, and for heavy work they are too light. In making tongs, several things should be taken into consideration, such as the shape of the stock they are intended to hold, where to leave the most material to resist strain, and the parts most liable to wear out. For flat tongs the jaws should be heaviest near the joint, and taper toward the point. The point should be about half the thickness of the width of the jaw. The reins should be round on the edges and taper gradually from the joint to the tip, which will give

them elasticity, and afford a comfortable grip for the hand. Care should be taken to leave no sharp corners around the joint, as it is there that the tongs are most liable to break. Flat tongs should have a small V shaped impression the full length of the jaw, so that they can be used to hold square stock cornerwise, or round stock. Fig. 8 shows a pair of flat jawed tongs of about the proper proportions for holding ½-inch flat, ½-inch square or ⅝-inch round stock. Barring accidents, this style ought to give the maximum of service. This type of tongs can be used for stock of the smallest sizes up to two inches. For larger sizes of flat stock the tongs ought to have one

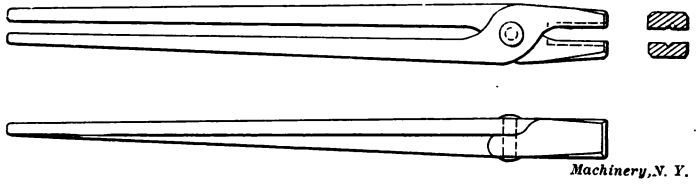


Fig. 8. Approved Type of Tongs with Flat Jaws

box jaw, or a jaw with a cross section on the point with lips turned up, to prevent the work from moving edgeways. The tongs shown in Fig. 9 are the most convenient style for holding round or square stock, the V-shaped jaws giving them a perfect grip on square work, and a bearing on four points on round work. This gives them an advantage over the circular jawed tongs commonly used for round stock, as these only have two bearings. The goose neck section between the jaw and the joint is also an advantage, as it will accommodate a burr or irregularity on the end of a piece of iron or steel which

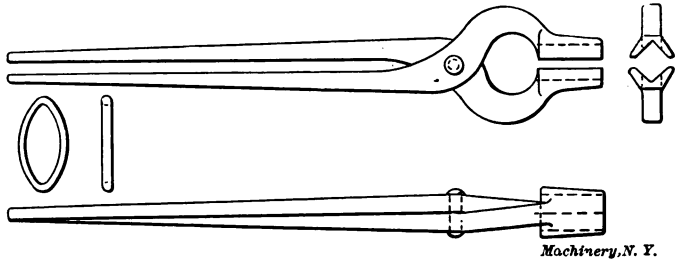


Fig. 9. Tongs with V-shaped Jaws

is usually found after it has been cut with shears or with a saw, while the bar is hot. Tongs of this shape can be used up to 5 inches capacity. For holding them upon the work, the style of link shown in Fig. 9, in enlarged scale in proportion to the tongs, should be used. Being made narrow at the ends, it has the advantage of hugging the reins tightly, and having two bearings on each rein makes it less liable to fly off than the link with circular ends.

For work over 5 inches, the style of clamp shown in Fig. 10 should be used. This clamp can be bolted firmly to the work whether it be round or square, and can be operated with the small clamps with

handles, attached to the shank in the same manner as to a porter bar. For heavy work, clamps are a great deal safer than tongs, and can be made to handle flat or irregular shaped pieces. For fastening the clamp to the work, the bolt shown in Fig. 6 is the most suitable, it

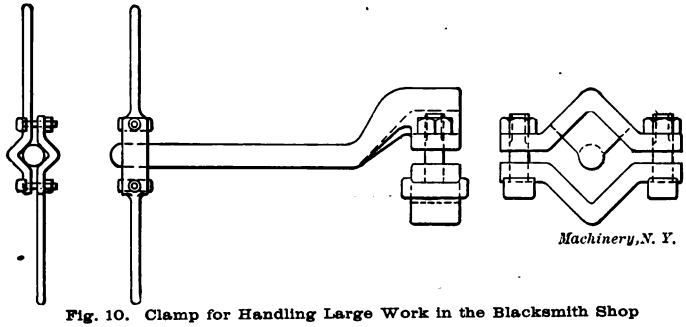


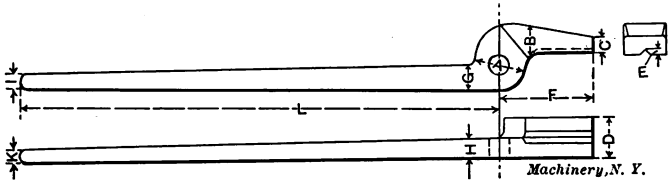
Fig. 10. Clamp for Handling Large Work in the Blacksmith Shop

having a cross head with lugs to keep it from turning, and it can therefore be tightened or unscrewed with one wrench.

General Remarks on the Efficiency of Blacksmith Shops

In nearly every blacksmith shop there is work to be done which can only be accomplished with special tools about which it would be

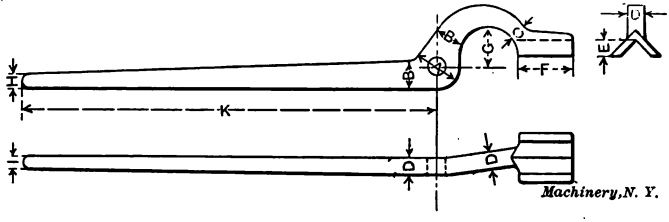
DIMENSIONS OF FLAT-JAWED TONGS



Nominal size of Tongs.	Diameter at Joint	Thickness of Jaw at Base.	Thickness of Jaw at Point.	Width of Jaw at Point.	Depth of V.	Length of Jaw	Width of Reins at Base.	Thickness of Reins at Base.	Width of Reins at Point	Thickness of Reins at Point	Length of Reins	Size of Rivet.
Inches.	A	B	C	D	E	F	G	H	I	K	L	M
0 – ½	⅝	⅞	¼	⅝	1/16	2½	½	5/16	5/16	¼	14	¼
9/16 – ⅝	⅞	7/16	5/16	⅝	1/16	2¾	9/16	5/16	5/16	5/16	15	¼
¾ – ⅞	⅞	½	5/16	⅝	1/16	2¾	9/16	5/16	5/16	5/16	16	5/16
¾ – ⅞	1	9/16	5/16	⅝	1/16	2¾	9/16	5/16	5/16	5/16	18	5/16
¾ – ⅞	1	9/16	5/16	⅝	1/16	2¾	9/16	5/16	5/16	5/16	20	5/16
1 – 1⅛	1⅛	11/16	3/8	⅞	1/16	3	¾	7/16	½	3/8	22	½
1¼ – 1⅜	1⅜	¾	7/16	1	1/16	3¼	⅞	7/16	½	7/16	24	5/16
1¼ – 1⅜	1⅜	¾	7/16	1	1/16	3¼	⅞	7/16	½	7/16	26	5/16
1½ – 1⅝	1⅝	⅞	½	1⅛	1/16	3¾	1	½	⅝	½	28	⅜
2	1¾	⅞	½	1½	1/16	4¼	1⅛	¾	11/16	½	30	11/16

impossible to give any intelligent information without seeing the pieces to be made; but whenever the quantity is such that it will justify the making of special tools, it should be done. A former or a fixture will not only reduce labor and cost, but makes the work more uniform. It is no exaggeration to say that at the present time very few blacksmith shops give more than 75 per cent of their possible efficiency, and others not more than 50 per cent, simply for lack of tools, system, and good executive guidance. A little consideration and

DIMENSIONS OF GOOSE-NECK TONGS



Nominal Size of Tongs.	Diameter at Joint.	Width at Base of Goose-neck and at Base of Reins.	Width of Goose-neck near Jaw.	Thickness of Goose-neck and of Base of Reins.	Depth of Jaw.	Length of Jaw.	Depth of Goose-neck from Center Line.	Width of Reins at Point	Thickness of Reins at Point.	Length of Reins.	Size of Rivet.
Inches	A	B	C	D	E	F	G	H	I	K	L
¼ - ⅝	⅝	½	7/16	5/16	⅛	1	½	5/16	¼	14	¼
⅜ - 7/16	¾	9/16	½	5/16	⅜	1⅛	9/16	5/16	¼	16	5/16
½ - ⅝	⅞	⅝	9/16	3/8	¼	1¼	⅝	3/8	5/16	18	⅜
¾ - ⅞	1	¾	⅝	7/16	⅜	1½	¾	3/8	5/16	20	7/16
1 -1⅛	1⅛	⅞	11/16	½	½	1¾	⅞	7/16	⅜	20	½
1¼ -1⅜	1¼	1	¾	9/16	⅝	2	1	½	⅜	22	½
1½ -1¾	1⅜	1⅛	⅞	⅝	¾	2⅛	1⅛	½	7/16	24	9/16
1⅞ -2⅛	1⅝	1⅜	15/16	¾	1	2¼	1¼	9/16	7/16	26	⅝
2¼ -2⅜	1½	1¼	1	¾	1⅛	2½	1½	9/16	7/16	28	⅝
2⅝ -2⅞	1⅞	1⅝	1 1/16	¾	1¼	2¾	1⅝	9/16	7/16	30	¾
3 -3¼	1⅝	1⅜	1⅛	¾	1½	3	2	⅝	½	32	¾
3½ -3¾	1¾	1½	1¼	¾	1¾	3¼	2¼	⅝	½	34	¾
4 -4¼	2	1⅝	1⅜	13/16	2	3½	2½	11/16	9/16	36	¾
4½ -4¾	2⅛	1⅝	1⅝	13/16	2⅛	3¾	2¾	11/16	9/16	38	¾
5	2¼	1¾	1⅞	⅞	2¼	3½	3¼	¾	⅝	40	⅞

a little outlay of capital would be a good investment, as in the majority of cases it would raise the blacksmith shop from being a "drag" to one of the most remunerative departments in a manufacturing plant.

The blacksmith has more difficulties to contend with in doing his work than any other class of mechanics. As a rule he is heavily handicapped in not being provided with tools and appliances enabling him to do his work quickly and economically. To a certain extent he may be compared with the pattern-maker; he has to start his work, in the first place, with nothing to guide him except a blue-print or a

sketch, often one-quarter or one-eighth size. This is all that is required if the work is plain and of regular shape; but if it happens to be bent, curved, or in the least complicated, it must be laid out full size, and a templet made before the actual work can be commenced. As compared with this, the machinist, and the majority of other mechanics, have their work shaped or partly shaped before it is turned over to them, which makes it comparatively easy. The pattern-maker can do most of his work at the bench; he can turn it around, and place it in any position to suit his convenience; he can stop at any time, and think over what his next move should be; he can cut, carve, glue, and build up, handling the work with his bare hands from the time he starts until it is completed. The blacksmith, however, is confined to the anvil or the steam hammer; his material must be heated before it can be worked to shape, and he must therefore handle it with tongs and lift and turn it with a crane if it is of large size; he has to make his plans and know exactly what his next move is to be while the material is heating, so that he will be able to

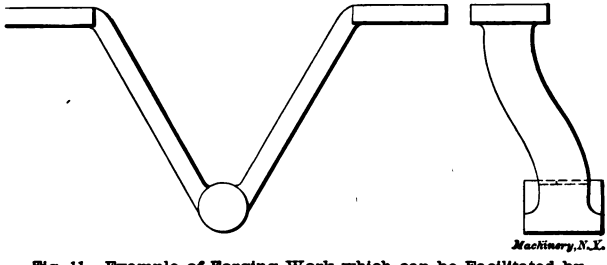


Fig. 11. Example of Forging Work which can be Facilitated by Using a Surface Plate

do the greatest amount of work while the heat lasts. Unlike other mechanics he cannot, as a rule, cut his work to shape, but draws, upsets, and bends it until it is ready for the machine shop.

Surface Plates

To enable the blacksmith to do his work with convenience and accuracy, it would be well to supply him with some of the appliances that save time and reduce cost. In most blacksmith shops, forgings of odd and irregular shapes are, at times, made. Let us take the piece in Fig. 11, for example, which, while not complicated, would be a difficult piece to make with any degree of accuracy without a surface plate for trying the offset and the alignment of the different points. The surface plate shown in the half-tone, Fig. 12, is of a style best suited for machine blacksmithing. It was designed by a practical blacksmith and constructed so that it would meet, as far as possible, the requirements of the blacksmith shop. Being mounted on wheels, it can be moved around the shop to the place where it will be most convenient for the workman using it. The face is graduated in inches, which allows pieces being placed parallel with the plate and measured. Offsets and curves can also be gaged more accurately than would be possible if working from chalk lines. A T-slot, about four

inches from one side, running the entire length, can be used for holding formers or similar tools to the surface of the plate. By using a square and a surface gage, the most complicated forgings can be made so nearly correct that there should be no trouble when machining the work.

A small surface plate of the same style should be provided for each forge. This plate need not necessarily be larger than eighteen or twenty-four inches square, with the face from 1¼ to 1½-inch thick. The plate is reinforced by ribs similar to those shown in Fig. 12. The wheels can be omitted, and a bench used to support the plate. A shelf may be placed between the plate and the base to accommodate clamps, bolts, etc., that may be used to hold work in position.

Vises

Benches with vises, attached to the walls of blacksmith shops, are not to be commended. There being no one constantly employed at the bench to keep things in shape, it is liable to be used as a place for

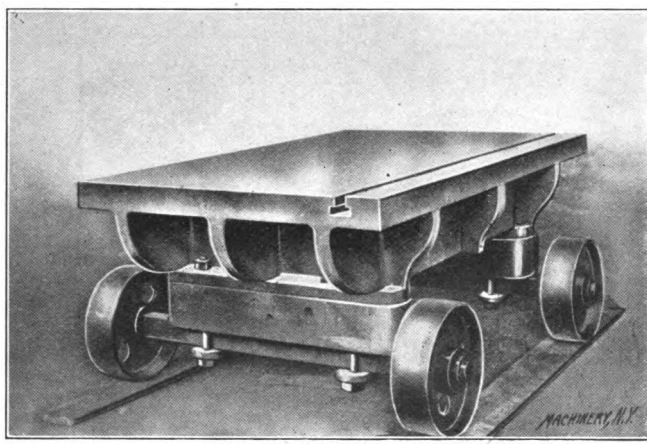


Fig. 12. Portable Surface Plate for Use in Blacksmith Shop

dumping "any old thing." This not only gives the bench an untidy appearance, but makes it necessary to clear up the space every time the bench is used. With a portable vise and bench this difficulty would be overcome. Every man using the bench would be expected to clear off every tool and piece of material before returning the bench to its place in the shop. Vises attached to a portable cast iron bench mounted on wheels can be moved around the shop to the place where they will be most convenient, saving time that would be wasted if a number of pieces had to be taken to the vise separately for some operation, especially if it happened to be located in some distant corner of the shop.

Tool Grinders

An emery wheel is a very essential piece of machinery for the blacksmith shop, as it is necessary to grind chisels and other tools

quite often. If they have to be taken to another department for grinding, it means the waste of considerable time both for the blacksmith and his helper. No matter which one of them goes to do the grinding, the other generally takes a rest until the absent one comes back. Almost any type of grinder would answer the purpose, but the style known as the wet grinder is the most suitable, especially if arranged to supply the water automatically; otherwise it is liable to be used as a forging machine, which is bad practice for the blacksmith and poor usage for the wheel.

Power Hack-Saws

For cutting up stock and trimming the ends of forgings, such as shafts, spindles, or similar work, a power hack-saw can be used to good advantage. It requires but little attention, so little, in fact, that the blacksmith or his helper could attend to it between the heats without in the least interfering with their work at the forge. It cuts

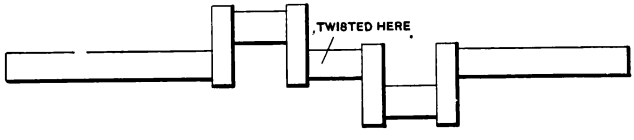


Fig. 13. The Crank-Shaft to be Forged

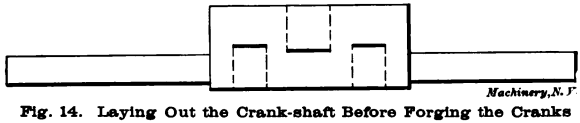


Fig. 14. Laying Out the Crank-shaft Before Forging the Cranks

off the ends of forgings neater than is possible by hand, and the time it saves means increased production without increasing cost. It can also be used to advantage in the process of forging various pieces. Take small crank-shafts for example, as shown in Fig. 13, which are usually forged with the crank or throw solid. The stock between the webs must be removed either by drilling small holes around it, or by using a slotting machine. By using a hack-saw, the crank can be put in shape for the lathe before it leaves the blacksmith shop. The stock intended for a crank should be wide enough for the throw on one side, the journals should then be drawn out and rounded, after which the piece between them should be laid out as shown in Fig. 14, care being taken to keep the distance between all the webs short enough to allow for drawing in rounding the bearings. A small hole should be drilled at each corner for the hack-saw to run into. When the hack-saw has cut along the dotted lines, the crank can be heated, and the pieces removed with a chisel applied where solid lines are shown in Fig. 14. When the bearings are rounded, the crank-shaft can be heated and twisted so as to bring the throws on opposite sides of the forging. Any number of throws can be made in the same manner and could be set at any angle by using a surface plate.

Portable Forges

The majority of up-to-date concerns manufacturing heavy machinery have a number of portable motor driven machines which can be taken to the work when it is inconvenient to take the work to the machine. These machines are usually credited with being time and labor savers, and, as a rule, cost less to manipulate on certain kinds of work than would machinery installed in a permanent position. Portable motor-driven appliances for the blacksmith do not, however, seem to have received much thought or attention up to the present time. Yet, there is no mechanic who could use portable appliances to better advantage than the blacksmith. A portable forge with a motor-driven blower attached could, perhaps, be used for a greater number of purposes

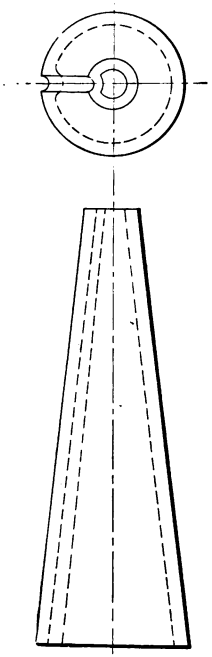


Fig. 15. Taper Cone for Forging Rings, Collars, etc.

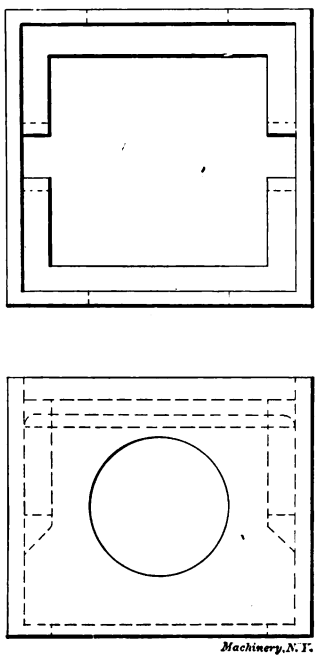


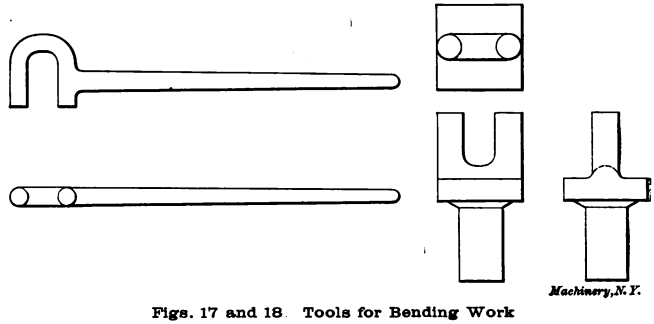
Fig. 16. Base for Swage Blocks

than any other portable appliance. Long pieces could be welded in the majority of cases with less trouble than with an ordinary forge. Such a forge could be used for heating braces or similar work in fitting them to castings or tanks. In short, any kind of work that is done at the ordinary forge could be done at any time or place where the appliance could be connected with electric power. If mounted on small wheels or casters and fitted with a handle of the style used for small trucks, this forge could be moved around anywhere with very little trouble, and work of larger dimensions could be handled than is possible with the portable hand forge commonly used for work done outside the blacksmith shop.

Miscellaneous Tools

Some shops are provided with taper cones or mandrels for truing up rings or similar work. A set of taper cones, of which there are several styles on the market, is inexpensive, and well worth a place in the blacksmith shop equipment. The kind that is most convenient to use and gives the most satisfaction is shown in Fig. 15. This style of cone has a U-shaped groove its entire length, which permits tongs to be used to remove or place work upon it more conveniently than with the unslotted kind.

Swage blocks take the place of a large number of individual tools, particularly bottom swages and heading tools. There probably is a larger variety of shapes and sizes of swage blocks than of any other blacksmith tool on the market. The style that comes nearest meeting the requirements of machine blacksmithing is the square pattern with circular, hexagon, and V-shaped impressions around the outside edges, and square and round holes of different sizes in the center; one side of these holes should be countersunk. If mounted on a cast iron base or block, such as shown in Fig. 16, the swage block can be conveniently



Figs. 17 and 18. Tools for Bending Work

used either for swaging or heading forgings, by standing it on its edge in the recess in the center of the block, or laying it flat in the flanged section at the top.

In bending work to curves or sweeps, dogs of the style shown in Figs. 17 and 18 will answer the purpose better than any other tool. They can be used either on hot or cold work. The tool in Fig. 17 is intended to be used by hand in combination with that in Fig. 18, which latter should fit the square hole in the anvil. In making tools of this kind, it is important that the one to be used by hand be as shown, so that its bearing upon the work will be in line with the end of the handle; this prevents twisting on flat work or slipping on round work.

A tool for bending open eye-bolts or hooks is shown in Fig. 19. The shank of this tool is intended to fit the anvil. The part *A* is an adjustable guide for forming the first bend marked *P* on the eye-bolt shown. At *B* is shown a grooved roller which bends the eye to shape when turning the handle *E* from the left to the right as shown by the arrow. At *C* the lever is jointed, which allows adjustment for different sizes of material, and permits the roller to follow the shape of form-

ing pin *F*, should its shape be other than round. The loose bushing shown at *D* is used to increase the size of forming pin *F* for making larger hooks or eyes. The bushings may be of any shape, but if other than round, they should be held in position by dowel pins. Tools of this kind should be fitted with an adjustable gage, so that the right amount of stock will be used for each piece. Hooks or eyes made on a tool of this type will not only be neater and more uniform in shape, but can be made in one-quarter of the time required if made by hand.

An appliance that would save time and trouble, and prove itself a great help to the blacksmith, is a small crane or hoist for each forge, to be used only for work at the anvil. When too long or heavy for one man to handle, it is often necessary for the blacksmith to get another man to help him to handle heavy work. If trestles or "horses" are used, they must be moved or adjusted in height every time the piece is turned or moved, which often takes as much time as is used in

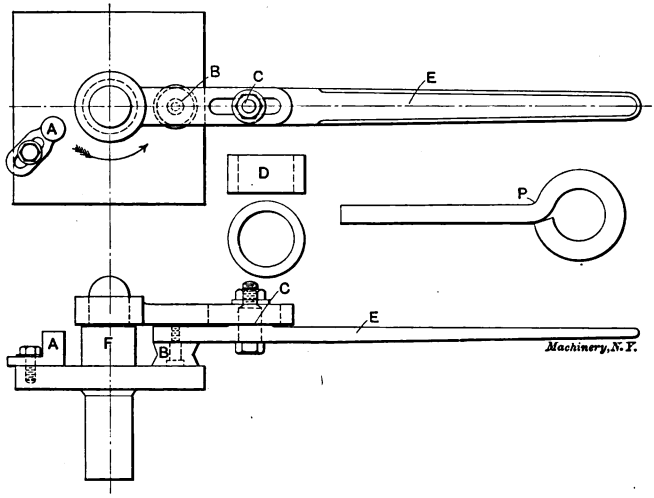


Fig. 19. Tool for Forging Open Eye-bolts or Hooks

doing the work itself. A small crane made of structural shape steel or steam pipe, properly trussed and braced, and fitted with a 1,000-pound chain hoist and snatch block, would overcome most of the difficulties. It could be easily adjusted to any height or position, would not come in the blacksmith's way, and would always be found in its place when wanted.

No blacksmith shop equipment is complete without platform scales for checking the weight of forgings and weighing stock before being used. It takes less time to weigh any kind of iron or steel than it does to figure out its cubic capacity and weight.

Machine Equipment of the Blacksmith Shop

Machinery and tools help the blacksmith as much as any other mechanic; they make it possible for him to do more and better work, increase production and reduce cost.

In selecting machinery for the blacksmith shop, a practical blacksmith who has had experience on the class of work for which the machines are intended, should be consulted, so that the equipment selected would be in proportion to the work to be done. It is not uncommon to find blacksmith shops equipped with hammers out of proportion to the work to be done, either too small or too large. In either case, it is evident that the working of the blacksmith shop is uneconomical. It is poor economy, in equipping a blacksmith shop, to provide it with too few steam hammers in proportion to the number of forges, as it requires the smiths to wait for their turn, and the time thus wasted will in the long run be worth a great deal more than the interest on the original investment in one or more additional steam hammers. Not only is this waiting for the use of tools uneconomical in regard to the time wasted, but the steel is, in many cases, injured by having to wait too long in the fire after it is hot enough for working. If steel is thus left in the fire, it may get a pitty and rough appearance when the forging is completed, and in the case of tool steel, the surface will be decarbonized to a certain extent, and the tool will not give as good service when used for a cutting tool.

General Notes on the Economy of the Blacksmith Shop

The economy of the blacksmith shop is also largely affected by the condition of the material supplied to the shop. If the blacksmith shop is supplied with material in long bars, these can be cut into the right lengths for the required forgings, and there will not be any waste, excepting, perhaps, a small piece on the end of each bar. If, on the other hand, the material is supplied to the smith in short lengths or in odd pieces, there will most likely be a small portion of each of these pieces wasted, and weight for weight, a great deal more material will apparently be used for completing the same number of forgings, when using short stock than when using long bars.

It should not be forgotten that in most cases forging to shape is cheaper than machining to shape. Since high-speed steel became commonly used, the forging of spindles and similar work has been largely done away with, except in cases where large collars are formed on the spindle, for the reason that, using high-speed steel tools, the excess material can be removed so quickly that it is supposed to be simpler to turn these parts directly from the bar. However, even when using high-speed steel tools, it is seldom that work of this character can be machined from the bar as quickly and economically as it can be forged to the approximate shape, providing the blacksmith shop equipment is up to date. Not only is there a great deal of material wasted when turning off a large amount from the bar in order to form a shoulder or a collar, but the wear and tear on the machines where the work is performed and the time consumed outbalance, in many cases, the cost of rough-forging. Often a single blow from a steam hammer, where an inexpensive former or die is used, will do more to put the piece of iron or steel in the approximate shape required than could be done by an hour of machining.

If the blacksmith shop equipment is adapted to carrying out the forging of more or less complicated shapes, the scrap pile can generally be turned to good use, and considerable economy can be exercised in the use of new stock. Old pieces of machinery, which may be useless for the purpose for which they were originally made, may still contain good material, which can be used to make other forgings, of smaller dimensions, and may even save considerable work in the re-working as compared with the use of new stock. Lathe and planer tools, when too short for service, are quite often consigned to the scrap pile, when they could just as well be turned over to the blacksmith to be drawn down to smaller sizes and used for smaller work. Even the smallest sizes of tools, when worn down too short, can be drawn out and used in tool-holders or for boring bar cutters. Considering that high-speed steel costs anywhere from 60 to 80 cents a pound, and that a blacksmith can draw down to smaller sizes from 150 pounds to 300 pounds in a day, this would indicate a considerable saving in the steel tools. Of course, the scrap is always worth money,

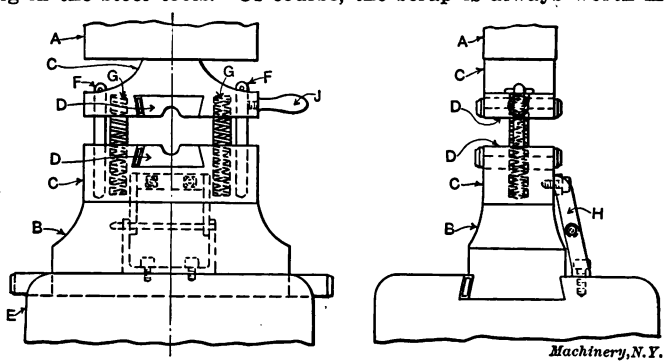


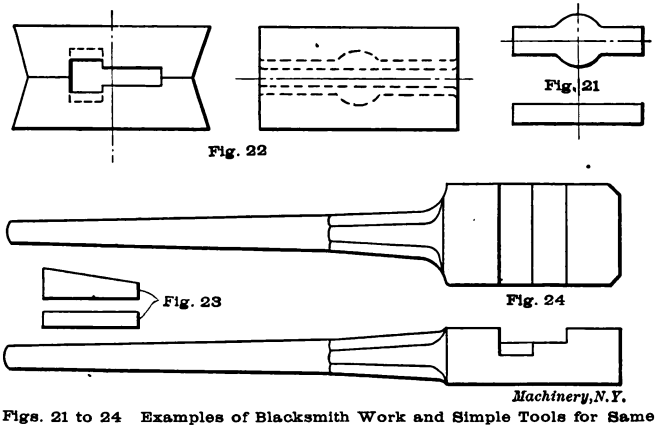
Fig. 20. Special Dies used for Economical Forging in the Steam Hammer

but the difference between the price of scrap and of new steel is too great to permit disregarding economy of this kind.

In order to help increase the efficiency, and to improve the quality and reduce the cost of work done in shops that are provided with only one steam hammer, the writer designed the steam hammer attachment shown in Fig. 20, which can be used for drop forging, swaging, forming collars, etc. This tool can also be fitted with shear jaws and used for cutting up material for forgings; or punches and dies can be fitted to it, and the tool used as a punch press. Being attached to the die chair of the hammer with jointed straps *H*, it can be used without removing the ordinary plain dies which can be used at any time by folding the attachment back in the open space between the hammer frame and the dies. This attachment can be used for all purposes that spring swages and other spring tools are used for, and will do superior work, because, being attached to the hammer, it is prevented from wabbling around while being used, as spring tools do. In making quantities of duplicate forgings, the attachment is a decided advantage over ordinary methods, both in the amount and quality of the

work done. The blacksmith's helper, not being required around the hammer to hold tools, can devote the most of his time to heating and handing the hot pieces to the smith. Should another smith want to use the hammer while the attachment is in position it can be folded back out of the way until he has worked his heat, and be placed in position again immediately after he has left the hammer. In the device shown, *A* represents the top die and *B* the lower die of the hammer. The parts *C* are holders for the dies *D*; *E* is the die chair, and at *F* are shown guide pins keeping the holders *C* in alignment. The springs *G* hold the dies open when no pressure is applied on the top, and *J* is a handle by which the attachment can be turned back out of the way when the plain dies are to be used.

The die holders *C* can be made either from steel castings or forged from machine steel. The lower dies *D* should be made from steel from 0.60 to 0.75 carbon and hardened. If the attachment is made so that



Figs. 21 to 24 Examples of Blacksmith Work and Simple Tools for Same

the spiral springs *G* will keep the dies a couple of inches apart, a jet of compressed air or a small pipe connected with the air supply from the blower could be used to keep the impressions of the dies free from scale; this would improve the appearance of the forgings.

Forgings of the style shown in Fig. 21 can be made in open dies, as shown in Fig. 22, which do not form any flash or fin, the only parts which need trimming being the ends of the forgings. The impressions are made wider than the forgings they are to shape, so that when a blow is struck by the hammer, the metal has room to spread. One impression shapes the forging edgewise, and the other brings it to the right thickness. When work of this kind is changed from one impression to the other at each alternate blow of the hammer, it can be completed in a very short time, and very close to size.

For forgings of the kind shown in Fig. 23 only one die or tool, as shown in Fig. 24, is necessary, the top die of the hammer being all that is required to form the top side of the forging.

The simple tools shown are used as examples to indicate how work

can be done economically in the blacksmith shop. The economy of the blacksmith shop depends largely upon the tools and the general equipment, but, of course, it is also required that the tools be handled intelligently, and the economical working depends in the last instance upon the class of men employed. Any department in the shop, and not least the blacksmith shop, requires men who understand how to use the appliances furnished to the best advantage. It is a mistake to think that the cheapest help procurable is good enough for the blacksmith shop. On the contrary, the economical working of the blacksmith shop requires the very best class of men.

CHAPTER III

ANVILS AND FORGES

The anvil and the forge are the two most important appliances of the blacksmith shop. Anvils are made in various shapes to suit different classes of work, but for all around work, and particularly for machine blacksmithing, no anvil gives better service than the standard pattern of solid wrought iron provided with steel face. This class of anvil is practically the only appliance used by the blacksmith that has been standardized. In general, it may be said that the anvil appears to have been developed along intelligent lines, and standard anvils are generally satisfactory with the exception that the square hole for the tool shanks is seldom straight or of exactly the same size in any two anvils of the same make and weight. This difficulty might be overcome by broaching the hole before the face is hardened.

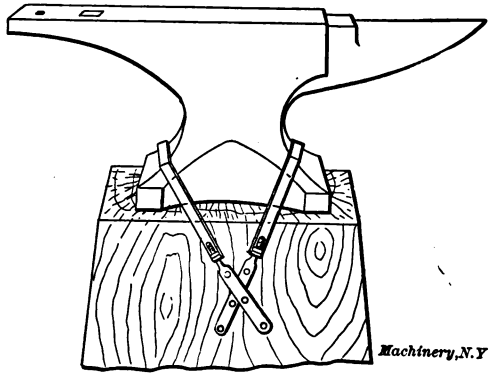


Fig. 25. Objectionable Manner of Holding an Anvil in Position

With this improvement, tools made to fit one anvil could be used elsewhere without danger of breaking the shank.

The quality of an anvil can generally be judged by its "ring," a good anvil giving out a sharp, clear sound when struck with a hammer; if soft or not free from flaws, the sound will be dull. A good anvil mounted on a block in such a manner that it gives out its full volume of sound is easier to work upon than one where the ring is deadened. There is a great deal of difference of opinion as to how anvils should be mounted, the general idea apparently being that it should be strapped fast to the block on which it is placed. If this were necessary, it is likely that the makers of anvils would have provided them with lugs or slots suitable for fastening them to the support.

When a wooden block is used under the anvil, it is necessary to use a few spikes to keep the anvil in place, but these should be placed

around the base in such a way that they do not bear directly upon it or pinch the corners. A common but poor way of holding an anvil in position is shown in Fig. 25. This method checks the vibration which tends to keep the face free from scales, and it renders a high-grade wrought iron anvil little better than if it were made from cast iron.

A mistake often made is the selecting of anvils too light for the work to be done. This may be done from a mistaken idea of economy, but light anvils do not give as good service or last as long as heavier ones. The 300-pound anvil is suitable for nearly any kind of machine blacksmithing, and if of this weight or heavier it will not move around when used, or need to be strapped to its block.

Wooden blocks must be sunk to a certain depth in the floor in order to keep them in place, and their height may have to be adjusted from time to time to suit a short or tall blacksmith. Cast iron mounting blocks are therefore preferable. An anvil mounted upon a block by a proper method is shown in Fig. 26. The block is made of cast iron,

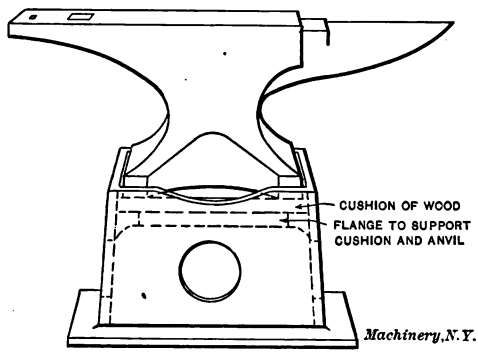


Fig 26. Correct Form of Anvil Block and Proper Method of Mounting Anvil

hollow in the center, with a flange 1½ inch wide by 1¼ inch thick, having a heavy fillet on the lower side where it joins the body of the block. On the inside, 2½ inches from the top, a piece of wood about 1½ inch thick and of the same size as the top of the block inside, is placed. This forms a cushion for the anvil to rest on. The top edges of the block in the back and front are made lower in the center than at the ends, permitting the scale and dirt from the work to find its way to the floor instead of getting under the anvil. A flange 3 inches wide all around the outside forms the base of the block and gives it a solid bearing on the floor. The location of an anvil mounted on this type of block can be changed at any time, and its height can be adjusted without much trouble. The wooden cushion gives a block of this kind all the advantages and none of the disadvantages of a wooden block.

In Fig. 27 the cast iron anvil block is shown in detail. It should be so adjusted when an anvil is placed upon it so that the face of the anvil will be inclined at an angle of about 3 degrees towards the front. This not only makes the work easier for the blacksmith, but

gives the scales a tendency to leave the face of the anvil on the side furthest from him.

Large pieces of hot metal, should never be left on an anvil longer than absolutely necessary, and in no case should hot work be left on the face of the anvil when the blacksmith leaves his work. If this is done, it will affect the temper and soften the face.

The Forge

The forge has been developed along somewhat less successful lines than the anvil. Different makers have turned out various types, if not a little better, at least a little different from their competitors'. There is scarcely a forge on the market which does not have the opening or openings of the tuyere at the lowest point of the fire pan, which is the place where clinkers and slag collect, and the opening of the tuyere gets filled up if not constantly cleaned out. To overcome

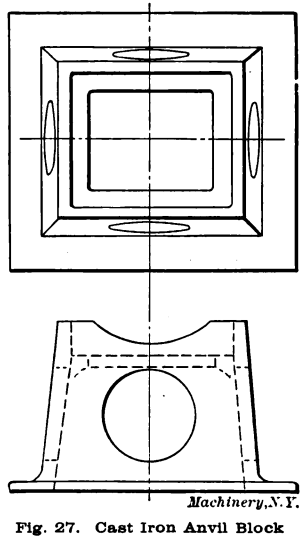


Fig. 27. Cast Iron Anvil Block

this evil, some forges have a shaker, which in turn has brought about the enlarging of the opening of the tuyere to accommodate the shaker. This not only has a tendency to spread the fire, making it almost impossible to take short heats, but clinkers and slag are worked through the tuyere into the air chamber or wind box until the blast is obstructed. The aim of the practical blacksmith is to have the forge and fire in such condition that he can concentrate the heat at some given point of his work when required. The lack of a suitable forge for this purpose on the market accounts for so many forges of the home-made variety being used. The home-made forge is usually very crude looking, but it serves its purpose. The material used for the top of the forge may be either stone, brick or a piece of the shell of an old steam boiler or tank, or even a wooden frame forge with sand up to the level of the tuyere. The writer has seen a very service-

able forge made from one-half of a large barrel. This was used for heating work up to five inches in diameter. This, of course, does not mean that wooden forges are recommended.

The most important features on a forge are the method of conducting the blast from the blower to the fire and a simple and effective means of getting rid of the smoke. In conducting the blast to the fire it must pass through the tuyere. There are two distinct types of tuyere, one with side, and one with bottom blast, either of which will give good service if properly constructed. The side tuyere, although little used in this country, is extensively used throughout Europe, and is preferable to the bottom tuyere for some classes of work, particularly when heating to an even temperature on all sides when the shape

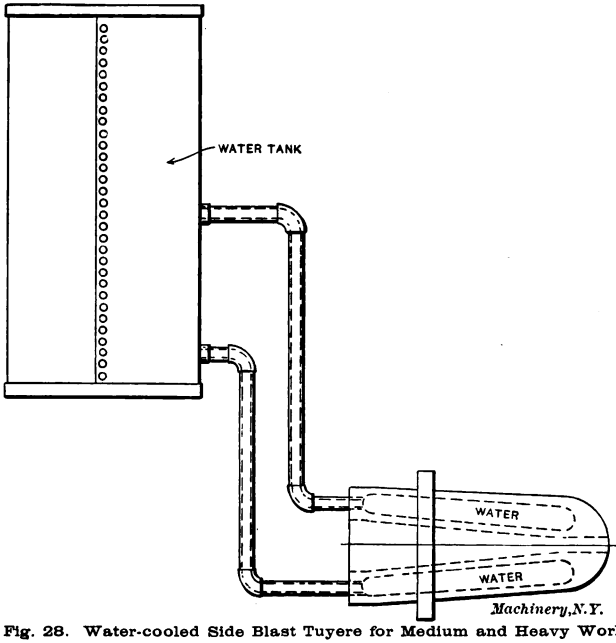


Fig. 28. Water-cooled Side Blast Tuyere for Medium and Heavy Work

of the work does not permit it to be turned in the fire. The work is then placed in the fire level with the opening of the tuyere and the fire is so arranged that the blast circulates freely over and under the work. A solid side tuyere with breast-plate is shown in Fig. 32. The shape is circular and slightly tapered, with a collar at about one-third of the entire length from the large end. The inside is hollow and tapers as shown. When placed in position in the breast-plate, the tuyere is forced as far through as the collar will permit, and is held in position by a yoke placed behind the collar. Two bolts connect the yoke with the breast-plate, which in turn is attached to the left-hand side of the forge by bolts. This tuyere is used for light forging.

For medium and heavy work a tuyere as shown in Fig. 28 is generally used. The principle of construction is the same as in Fig. 32,

but it consists of an outer and inner shell, the space between which is filled with water to keep the metal from being overheated. The water is supplied from a tank, to which it returns after it has passed through the tuyere. Sometimes tuyeres of this style are directly connected with a water tank without the use of pipes.

A simple and inexpensive but very efficient form of air chamber and tuyere for bottom blast is shown in Fig. 29. The air chamber *D* is made from a piece of wrought-iron pipe at least 4 inches inside

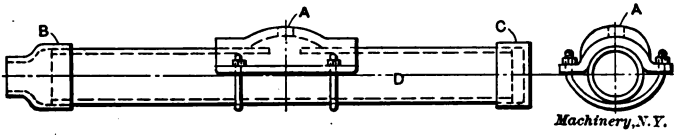


Fig. 29. Air Chamber and Tuyere for Bottom Blast

diameter. On the end projecting through the left-hand side of the forge a reducing coupling *B* is placed so that a pipe of 2½ to 3 inches diameter can be used to connect it with the air supply. On the other end, which projects on the right-hand side of the forge, a metal cap *C* is used, which closes this end. This cap can be unscrewed at any time for cleaning the air chamber. The tuyere *A* can either be made of cast iron or forged from wrought-iron and is held in position by two U-shaped bolts. Some fire clay or asbestos soaked in water and placed between the tuyere and the air chamber provides an air-tight joint when the bolts are tightened. When making a tuyere of this

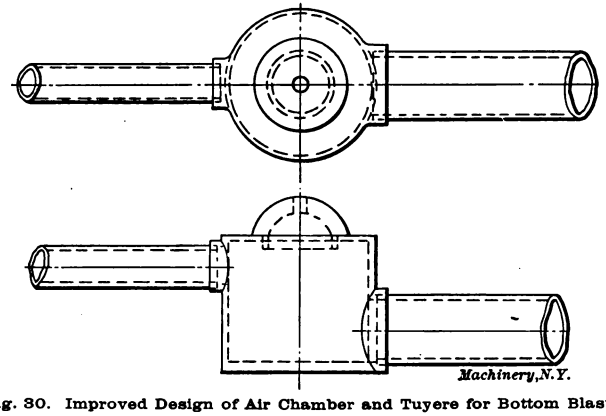


Fig. 30. Improved Design of Air Chamber and Tuyere for Bottom Blast

kind it is important that it be spherical or conical in the center and that the blast opening be at the highest point. Clinkers and slag will then collect at the base instead of directly over the opening. With a tuyere made in this way no shaker or other device is required to keep the opening clear. The air chamber is made larger than the pipe supplying the blast in order that a full air supply may pass through even when a small quantity of clinkers or slag have accumulated under the tuyere.

An air chamber and tuyere of somewhat improved design is shown

in Fig. 30. The air chamber is cylindrical with a circular opening at the top into which the tuyere fits. A small opening at the left near the top of the air chamber provides an inlet for the blast, and a larger pipe to the right provides means for cleaning. No bolts or other appliances are necessary to keep the tuyere in place, fire clay or asbestos placed under the flange making it air-tight and holding it in position.

In shops where the range of work is large and the number of forges is limited, tuyeres with different sizes of openings can be used in the same forges for different classes of work when made as outlined. For heavy work, a low tuyere with a large opening should be used, and enough fuel should be kept between the blast and the work to consume the oxygen before it reaches the work. For light work a high tuyere with a small opening is used, because it saves fuel and tends to keep the fire in a small space.

For machine blacksmithing forges should be from 36 to 42 inches in diameter and from 26 to 30 inches high, the top of the tuyere being from 4½ to 7 inches lower than the top of the forge. As there are no standards or definite data for guidance in determining the size of

TABLE OF SIZES AND ARRANGEMENT OF TUYERES

	Inch	Inch	Inch	Inch	Inch
Size of opening in tuyere	¾	1	1⅜	1¾	2
Distance between top of tuyere and top of forge	4	5	6	7	8
Size of supply pipe.....	1¾	2	2½	3	3½
Size of work to be done	¼ to 1	1 to 2	2 to 4	4 to 7	7 to 10

the opening for tuyeres or the depth at which they should be placed below the level of the hearth, the accompanying table gives what the writer considers to be proper dimensions for work varying from ¼ inch to 10 inches diameter, when the blast is delivered at a pressure of eight ounces per square inch or over. Work over 10 inches in diameter can be more uniformly and economically heated in a furnace.

Carrying off the Smoke from the Forge

The smoke is generally carried off with more or less success by means of a bell-shaped hood suspended over the forge and connected with the chimney. Without exception the bell hood is the worst form to use, as more smoke and gas is admitted at its base than the chimney is capable of carrying off, and the smoke spreads through the shop and escapes by doors or windows after having made conditions uncomfortable for the blacksmiths. Forges without hoods are preferable to the bell hood, provided there are means for ventilation in the roof of the shop, as then the gases can rise freely and escape. Another objection to the bell hood is that it prevents a crane from being used to any advantage over the forge. In order to overcome the drawbacks mentioned some concerns have installed the down draft system in their blacksmith shops. This system has its advantages; no overhead pipes, smoke or gas have to be contended with and the equipment is ideal for training schools and similar places, but for the practical

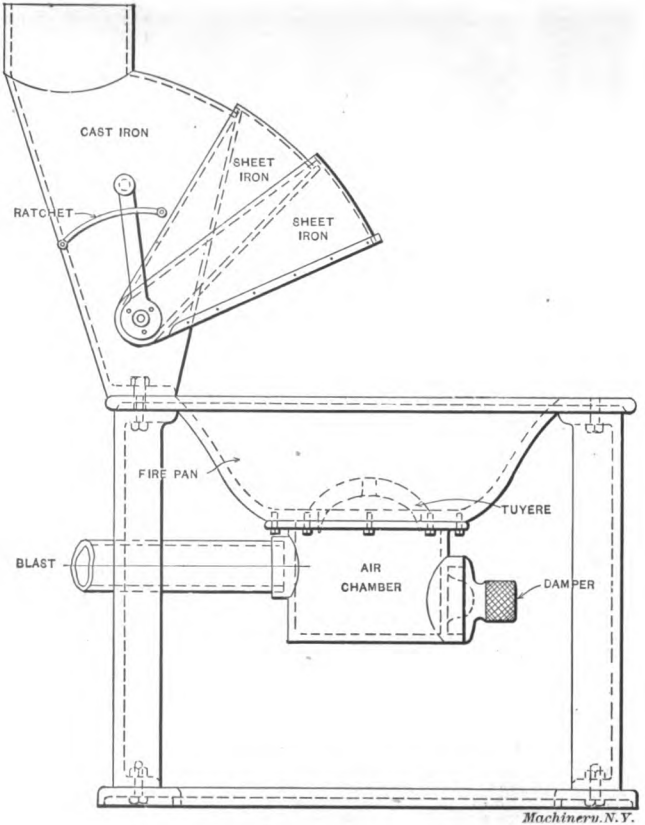


Fig. 31. Skeleton Forge with Cast Iron Hood Frame and Adjustable Sheet Iron Folding Hood

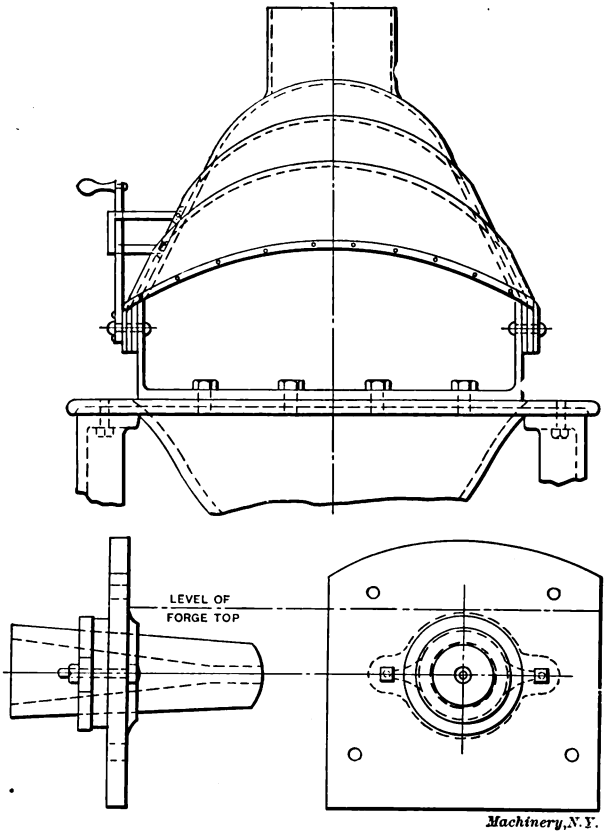


Fig. 32. Solid Tuyere for Side Blast for Light Work

blacksmith shop, where the cost is an item of first importance, it presents disadvantages; it is designed to work in direct opposition to the laws of gravity, and the amount of power necessary to create enough suction to draw the smoke and gases down is too great.

A forge and hood, which give good service both for heating work and for carrying off the smoke when individual chimneys are used for each forge, or when connected with a draft system, is shown in Fig. 31. The body of the forge is of cast iron and constructed on the skeleton plan. This allows of tools or other appliances too large for the tool bench to be kept under the forge. The tuyere and air chamber are practically the same as shown in Fig. 30. The main part of the hood is of cast iron and is placed on the left-hand side of the forge where it is held in position by bolts. The chimney is placed to the left as shown and out of line with the top of the forge, and therefore permits of a crane being brought directly over the fire and the work. The adjustable parts of the hood are made of sheet metal, reinforced at the edges with band iron and joined near the base so that they can be let down close to the forge when a new fire is being built, or folded back to the base of the chimney, leaving the whole top of the forge clear when required. The chimney should never be less than 8 inches inside diameter. The forge here shown was designed several years ago and has been in use continually and has given satisfaction on all kinds of machine blacksmithing from ¼ inch to 10 inches in diameter.

CHAPTER IV

POWER HAMMERS AND FORGING APPLIANCES

Power hammers, previous to the advent of steam, were of the helve and trip type, usually operated directly by the shaft of a water wheel, and principally used in the manufacture of wrought iron and steel. They were crude, cumbersome, but they were equal to the needs of a past generation of iron and steel workers, who were more noted for the thoroughness with which they did the work than the speed with which it was accomplished.

The steam hammer was invented by James Naysmith about 1842. Naysmith's hammer was direct acting, and was a decided improvement over the helve and trip types; but it was defective in several ways. The valves were operated by hand, and it was often difficult to raise the ram immediately after a blow was struck. This had a tendency to chill the metal being worked. The steam hammer remained in this condition until Robert Wilson applied a valve motion which enabled the blows to be regulated both in speed and force, placing the hammer absolutely and at all times under perfect control of the operator.

The steam hammer has been the most potent factor in the development of the iron and steel industry. When considering the important part it has played in the development of machinery, and the effect it has had upon progress and civilization, it is natural to suppose that no pains would have been spared in perfecting the steam hammer. This has, however, not been the case, and the steam hammer of to-day is but slightly superior to that made by Naysmith and Wilson. The improvements made since it was originally invented have mostly been on the valve, the guides for the ram and the general construction of frames. Minor details, in the majority of cases, have been left to take care of themselves.

Take, for example, the arrangement of the hand levers on most of the single-frame hammers in general use. It will be found that the greater part of them are made as shown in Fig. 33. To manipulate levers arranged as shown, the operator is placed not only in a cramped, awkward position, but so that he can only with difficulty see the work being done. The controlling lever *A* being held in the right hand, makes it necessary for the operator to use his left hand for the throttle lever *B*. When working under a full head of steam, his left arm comes directly in front of his face, obscuring his view of the work. He must remain in this position until the operation on the work is completed; should he release his hold upon the throttle lever, the jar of the hammer would immediately bring that lever to the perpendicular position and shut off the steam. The operator's view of the work being obscured is also often responsible for his mistaking the signs

which must necessarily be used while work is being done at a steam hammer on account of the noise. On some makes of hammers this defect has been overcome by placing both levers on the same stud, and operating the throttle by means of a connecting rod connecting the lever with a short lever directly attached to the stem of the throttle valve, as shown in Fig. 34. This permits the operator, at all times and under all conditions, to get an unobstructed view of the work.

The methods of attaching the levers may also be improved. The usual method for attaching the levers is shown in Fig. 35. The levers are fitted or at least placed on round stems and kept from turning by keys. A taper pin is driven through the boss on the lever and the stem to keep it in place. It is, generally, but a very short time before levers attached in this manner work loose, no matter how well they may be fitted. Lost motion is an annoyance on any kind of machinery, but is actually dangerous on a steam hammer. If the levers were

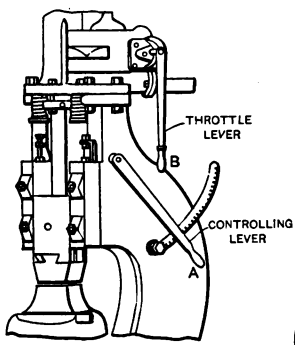
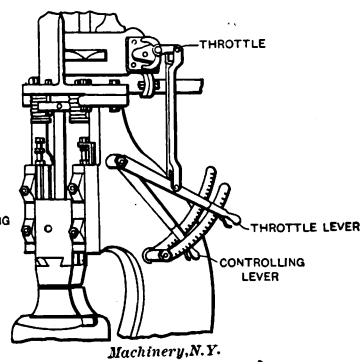


Fig. 33. Single Frame Steam Hammer, showing Common Arrangement of Levers



Machinery, N.Y.

Fig. 34. Improved Arrangement of Throttle Lever

made with a binder across the end of the boss, as shown in Fig. 36, and fitted to square stems, there would be little danger of lost motion, or of the levers working loose; and their removal when repairs are necessary would be an easy matter compared with removing pins and keys.

There is also room for improvement on the common method of fitting and attaching the anvil-block to the base. Almost invariably the male part of the dovetail is a projection of the anvil-block and fits into a recess in that part of the base which projects through and a little above the flange which forms the base of the frame, as shown in Fig. 37. Should the key which is necessary to hold anvil-block and base firmly together be driven in too tight, the chances are that the side of the recess will be broken away. When this happens, there is no possible means of effecting repairs and the base must be replaced by a new one, which can only be done by disconnecting all pipes to and from the hammer and raising the whole frame to allow of the old base being removed and a new one placed in position. Apart from the work and expense, the hammer is out of commission from one to

two weeks. If the dovetailing was reversed, making the male portion part of the base, as shown in Fig. 38, it would be almost impossible either to break or damage the base accidentally, as the driving of a key however tight would only tend to compress it. Should the anvil block happen to be broken, the replacing of that would be but a trivial matter compared with replacing the base.

Upon nearly every other class of machinery weaknesses and defects of the kind mentioned have either been overcome or guarded against by placing the pieces most liable to break in positions where removing or replacing them can be done at the least expense. The probable reason for the details of steam hammers not receiving the attention that is usually given to machinery used in other branches of metal

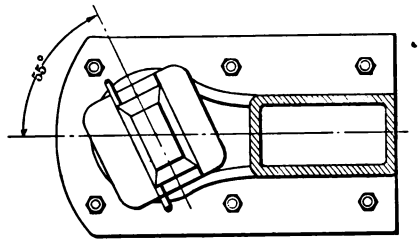


Fig. 35

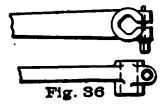


Fig. 36

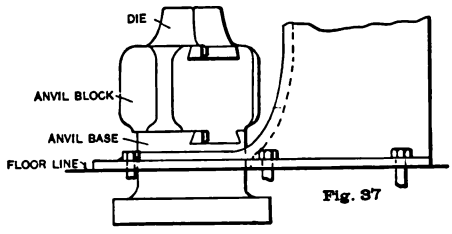


Fig. 37

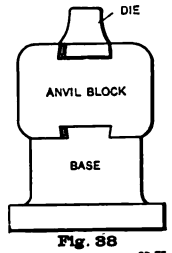


Fig. 38

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Fig. 35. Common Method of Attaching Throttle and Controlling Levers. Fig. 36. Improved Method of Attaching Levers. Fig. 37. Anvil and Dies of Steam Hammer set at an angle with the Frame; also shows Usual, but Objectionable, Method of Dovetailing. Fig. 38. Improved Style of Anvil Block and Base

working may be that designers as a rule never have any practical forge shop experience apart from that taught in the industrial departments of schools and colleges, which at the best is only elementary and does not, usually, bring them in contact with forging appliances other than those used by hand around the anvil. Much valuable information relative to steam hammers and other forging appliances could be gathered from the blacksmith, who has every opportunity of noting their efficiency, and their weak points as well; but suggestions from him, no matter what his experience may be, are seldom considered and rarely adopted.

Nearly all kinds of machinery used in the different branches of metal working, outside of the forge shops, are constructed so that they can be adjusted or set to work at any angle. Tool equipments for

any particular class of work are made and supplied, and all the data and instructions that will insure that the machine will give satisfaction in turning out work to its full capacity are given. When a special tool or a fixture for some particular piece of work is required, it is designed and constructed in strict accordance with mechanical principles. Steam and power hammers, however, are supplied with no tool equipment whatever, more than a plain-faced pair of dies which are of comparatively little use in the making of forgings without an equipment of tools to be used in connection with them. Such tools the builders of hammers do not supply, nor do they generally give any information that could be turned to good account in making them. It is usually "up to the blacksmith" who has to use such hammers and appliances, to design and construct such tools and fixtures as facilitate the making of forgings and make the machines paying investments.

Steam hammers are built in a variety of styles to suit the different classes of forging. The smaller sizes are of the single frame type, while those intended for the heavier work have an arched or double frame. For medium weight and light forging, the single frame ham-

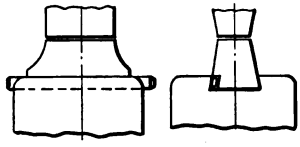
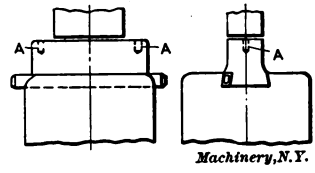


Fig. 39. Common Form of Dies



Machinery, N.Y.

Fig. 40. Improved Form of Dies for General Use

mer with the anvil and dies set at an angle of from 55 to 60 degrees from the frame, as shown in Fig. 37, will be found to be the most suitable, as work of any length can be forged either across or lengthways of the dies without its coming in contact with the frame.

Nearly all dies supplied with steam hammers are tapered from the shank to the face, as shown in Fig. 39, and are only suitable for plain straight forging, as it is impossible to work close up to a shoulder on a forging, on account of the taper, or to break down work except by using special tools, as the faces of both dies are the same length. If the dies were made as shown in Fig. 40, where the lower die is considerably longer than the upper one, with the sides of both perfectly straight, several advantages are gained over the more common shapes. The square sides allow of working close up to shoulders, and the extra length of the lower die permits of breaking down work without the use of special tools. Work is also much more easily straightened, and there is more space upon which to place formers or special tools. The hole at each end of the lower die, as shown at *A*, adds considerably to the utility, as these holes can be used for stakes to keep formers from moving while they are being used. Work of irregular shape can also be butted against the stakes while the hammer is used to finish some portion that otherwise would have to be done by hand. Forks

could also be used to keep spring swages from being moved with the work when forced or drawn through them.

To make a steam hammer as useful and handy a machine in the forge shop as a lathe with a taper attachment is in the machine shop, a lower die as shown in Fig. 41, can be used to draw and finish tapers to any angle. The rougher part of the work is done on the rounded end *B*, and the finishing on the adjustable end *D*. The level portion *C* in the center can be used for flat work. The adjustable section *D* of the die is about one-third of the entire length, semi-circular in shape, and corrugated on the lower side, which is provided with a T-slot. A T-headed bolt fits into the slot, and the adjustable section is held firmly in place at any angle by a wedge-headed bolt *E*, which is passed through a slot in the T-bolt and is tightened by a nut on the end which projects through the other end of the die. When the end of the adjustable section is raised above the level of the face of the die, as shown by dotted lines, a piece shaped as shown at *A* can be placed on the center of the die to prevent the upper die coming in contact with it.

To set dies of this kind accurately to any desired angle, the adjustable gage shown in Fig. 42 should be used. The gage is jointed at all

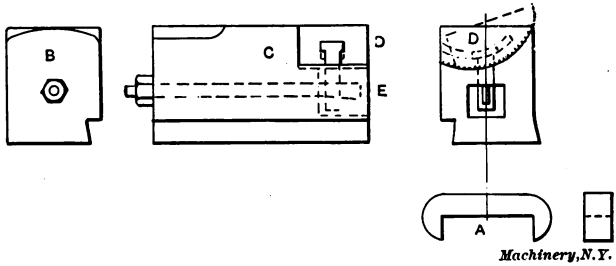


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Fig. 41. Adjustable Lower Die for Drawing and Finishing Tapers

the corners, and locked at any angle by means of a thumb-screw. It can be adjusted by means of a protractor and is used by placing it between the upper die and the adjustable section in the lower one while the bolt that keeps it in position is loose.

The arrangement of piping to and from hammers is also worthy of consideration. Generally both the supply and exhaust pipes are placed overhead, where they offer an obstruction to the free use of jib cranes, which are essential in the handling of heavy work. Besides, any steam that is condensed in the supply pipe, is supplied to the hammer in the form of water, especially when the hammer is installed any distance from the point at which the steam is generated. When water is supplied to a hammer in any considerable quantity, it generally finds an outlet other than the drip cocks and is one of the greatest annoyances to the workman. If it gets on the dies it is spread in a fine spray in all directions when a blow is struck.

The trouble with leaking water can be overcome to a great extent by placing both supply and exhaust pipes under the level of the floor

and providing the supply pipe with a trap which would take care of the greater part of the water caused by condensation. The fact that the steam is supplied from below instead of from above would tend to prevent water reaching the cylinder of the hammer in quantities sufficient to cause trouble. The absence of overhead pipes would allow of the free use of cranes or any other conveying devices.

Amongst forging appliances the steam hammer is paramount; it can be used for any kind of forge work from the lightest to the heaviest; but for some of the lighter grades of forging some of the lighter types of power hammers may be used with equal, and perhaps better, results than could be obtained with the average steam hammer, because they are lighter and capable of striking blows much more rapidly. When the term power hammer is used without qualification it applies to the types of hammers that are operated by a belt from a countershaft almost directly over them. The belt is just long enough to clear the lower side of the pulley attached to the hammer; it runs constantly and is rendered operative by a tightening pulley or idler controlled by the foot of the operator. Hammers of this type are generally referred to in the shop as trip hammers. The term is misleading, and is only a survival of the name applied to one of the earliest types of power hammers now almost obsolete. Power hammers are built in a variety of different styles, each of which is designed with reference to its adaptability to certain kinds of work that may be done by them somewhat more economically than by the other types.

The type of power hammers best adapted for general forge work are those with the ram running in guides. This arrangement insures their striking a square blow upon any size of material within their capacity. They require less adjusting than most of the other types, and their utility is such that they can be advantageously used for any operation in the making of light forgings with the exception of upsetting.

The helve hammer is extensively used for the making of any kind of light forging that can be done in open dies such as round work, edged tools, cutlery and springs. On this type of hammer the head is mounted on the end of a wooden beam which is cushioned both on the upward and downward stroke either by blocks of rubber or springs, making the blows, which can be delivered with great rapidity, very elastic. These hammers, however, are poorly adapted for general forge work because the head is raised and returned upon a radius which makes adjustment for each size of material necessary. If not properly adjusted, the side of the work nearest to the fulcrum will be drawn thinner than the side away from it. Generally the arrangement of dies in helve hammers as they are supplied by the manufacturer are as shown in Fig. 43, the rounded ends being toward the fulcrum. This is all that is necessary when the hammer is to be used exclusively for the drawing of stock to smaller dimensions, but for general forging they should be reversed, as it is often necessary to spread stock to greater width, which can only be done to advantage when the rounded ends of the dies are accessible. The dies could be

used equally well for all the purposes for which helve hammers are generally used if placed cross ways in the head and anvil.

When floor space is an item of importance, the upright power hammers of which there are various styles, are more suitable; they are equally as efficient, and can be installed and manipulated in less space than most of the other types.

Lately marked attention has been given to the development of pneumatic or compressed air hammers, which without doubt is a step towards progress. Pneumatic tools have proved their efficiency and utility in other branches of manufacturing, and there is no apparent reason why they cannot be advantageously used in forge shops, providing they are designed and constructed for that class of work. Com-

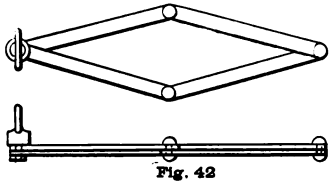


Fig. 42

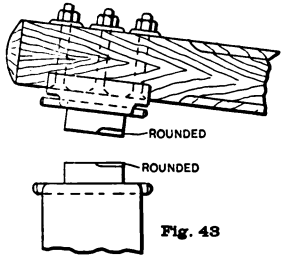


Fig. 43

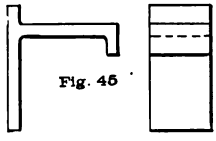


Fig. 45

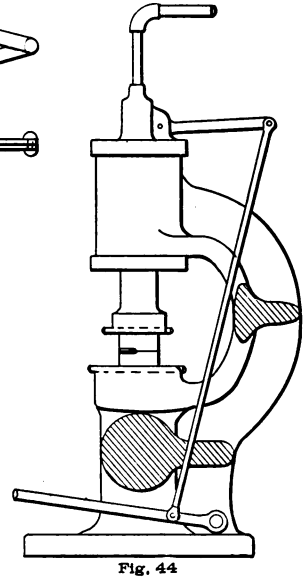


Fig. 44
Machinery, N.Y.

Fig. 42. Gage for Setting Adjustable Die to any Angle. Fig. 43. Common, but Objectionable, Way of Placing Dies in Helve Hammer. Fig. 44. General Appearance of Pneumatic Hammer for Light Forging. Fig. 45. Piece that can be forged to Advantage in the Forging Machine

pressed air is quite often used for the operation of ordinary steam hammers and has proved to be a very efficient substitute; but when it is possible to operate a hammer by steam directly, it can be done as effectually, and at less cost, than would be the case indirectly through an air compressor.

With the modern pneumatic hammer it is an entirely different case, as it is built self-contained with air compressor attached, and can be operated either by belt power or an attached motor, the advantage of which needs little explanation. No piping to speak of is required, power is used only while the hammer is being operated, and its utility for work within its capacity combines most of the advantages of steam and belt driven hammers.

There is another type of pneumatic hammer that so far has not received much thought or attention, but which has proved itself to be a valuable addition to the equipment of forge shops where it has been tried. The working parts are constructed upon the same principle as the hand pneumatic hammer used for chipping, and is simply larger and mounted upon a frame in the shape of a *C*-clamp supported by a column and base as shown in Fig. 44. Hammers of this type are so compact that they can be installed and operated in about half the space required for any other type of hammer of the same capacity. They can be used for the very highest class of forge work, and the exhaust from the cylinder can be utilized to keep the die free from scale, which is important when a smooth, clean forging is essential.

For making duplicate forgings in large quantities, there is no forging appliance that is so extensively used as drop hammers. As the term implies, the heads of drop hammers are raised to sufficient height for the required blow, released, and allowed to fall on the work being forged, after the principle of pile drivers. There are various methods of raising the heads of this class of hammers. The most common for forge work is by friction. A hardwood board is attached to the hammer head and passed between two rolls which rotate in opposite directions on the top of upright guides. The rolls are rendered operative by a mechanism controlled by the foot of the operator. When the head has been raised to sufficient height, a projection on the head engages a dog which releases the board from the rolls and allows the head to drop upon the work. Blows may be struck automatically or their force can be regulated at the will of the operator. Drop hammers are designated by their falling weight and are built in all sizes up to 3,000 pounds, which is the limit at which a friction drop can be successfully operated.

Duplicate forgings larger and heavier than can be economically made by drop hammers are either made by steam drops, which are practically steam hammers designed for the making of forgings in dies, or by hydraulic presses.

The only disadvantage in using hammers of the kind mentioned is that the dies used in connection with them must necessarily be made with from 3 to 5 degrees of draw in the impressions to allow of easy removal of the forgings after each blow is struck; scale also easily accumulates in the impressions and is worked into the surface of the pieces being made. Hot material left for any length of time in dies has also a tendency to soften them. It is therefore obvious that forgings of a shape other than round or oval cannot be made perfectly parallel on all sides except by more than one forging operation.

In the making of duplicate forgings such as are used on cars, wagons, agricultural implements, etc., where smooth surfaces are not so essential as shape, strength, and level bearings, there is no forging appliance than can be used to greater advantage than the modern forging machine. Take, for example, a forging of the shape shown in Fig. 45; it is plain, and looks as if it should not be difficult to make. This, however, is just the kind of work for which the drop forging process falls

short. By being roughly bent to shape it can, however, be forged complete at one stroke of a forging machine.

The bulldozer is also worthy of attention although it can not be used to advantage for work other than bending. In the modern forge shop it is indispensable for that work alone, as there is no bending job, however complicated, that can not be done by it with properly constructed fixtures.

If an equal amount of thought, ingenuity and skill were devoted to the improvement of forging appliances and methods of working hot iron and steel, that has been given to the manufacture and finishing processes in the machine shop, it would be just as easy for the blacksmith to make light forging within 1/16 inch, medium weight within 1/8 inch, and heavy pieces from 3/16 inch to 1/4 inch of finished size, as it is to turn out the shapeless pieces that must be hogged to shape by high-speed tools in the machine shop, where the part of the material that has been refined by hammering is removed, leaving the soft core for the finished product, at a cost out of all comparison with a good clean forging.

CHAPTER V

THE STEAM HAMMER AND ITS USE

One of the greatest changes in the way of improvement in the art of blacksmithing came with the steam hammer. It made possible the making of heavy forgings from one solid piece of iron or steel, which previously had to be made in sections and welded together. Welding is still necessary on a great many kinds of blacksmith work, but with the steam hammer it can be done in less time and to better advantage than is possible by hand. The majority of people, including blacksmiths, seem to have only one conception of a steam hammer, that of a piece of machinery intended for striking a heavy blow; this is the principal, but by no means the only purpose for which it can be used. With a good equipment of tools and a good operator it is possible to do nearly any kind of machine blacksmithing—all but the finishing touches—at the steam hammer. If necessary it can also be used to do drop forging and as a trimming press, shears, bulldozer, and vise, and for a variety of other purposes.

With all its advantages it is, as a rule, one of the most abused pieces of machinery to be found around a manufacturing plant. For every other kind of machine there is usually a skilled operator. If it happens to be operated by a boy, or any one else who does not thoroughly understand it, he is generally doing so under the directions of a competent man. For the steam hammer, as with every thing else in the blacksmith shop, anything is good enough—an ordinary laborer, a small boy, or any one who comes along, provided he can be hired for

a small amount of money, regardless of safety or economy. To get the best results from a steam hammer, however, as with any other kind of machine, it is absolutely essential that the operator thoroughly understands his business. He should be as conversant with the working parts and mechanism as an engineer should be with an engine, and should be able to do all minor repairing, such as packing glands, adjusting guides, valves, etc. As a machine operator, he should be classed with skilled labor, and paid according to his ability. Like all other

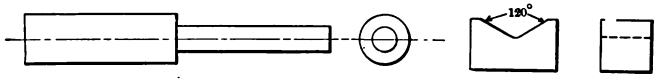


Fig. 46 Fig. 47

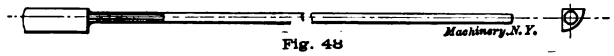


Fig. 48

Figs. 46 to 48. Example of Work, and Tools for "Breaking Down" Forgings

classes of help, really good steam hammer operators are scarce from the fact that the unskilled laborer usually gets the same rate of wages.

The purpose for which the steam hammer is principally used is to draw iron or steel to smaller dimensions in the making of forgings. This can be done to the best advantage if the dies are slightly crowned in the center, not necessarily over 1/16 inch for each die, and the edges rounded off to a radius of about 3/32 inch. Any one who has done work with a steam hammer will appreciate the advantage of having the die crowned. In drawing stock with perfectly level dies, the drawing is most in evidence where the edges come in contact with the

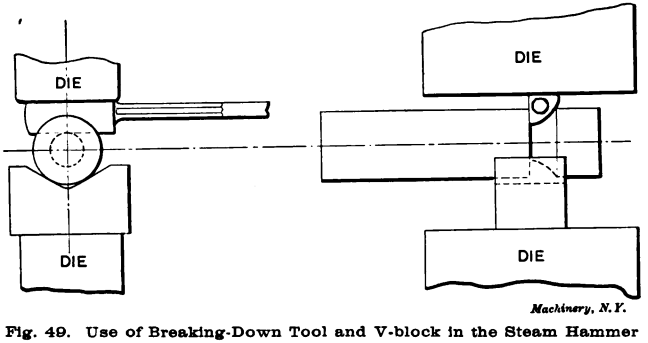


Fig. 49. Use of Breaking-Down Tool and V-block in the Steam Hammer

metal; in the center it is simply spread out, there being nothing in the dies themselves to give it a tendency to draw when a blow is struck by the hammer. With the dies crowned, a blow will be more effective, and the spreading of stock will be reduced to a minimum. It is also an advantage to have the sides of the dies square, so that in making forgings such as are shown in Fig. 46, the shoulder will be as near as possible at right angles with the body of the piece.

In "breaking down" stock for a shoulder, a tool similar in construction to Fig. 48 should be used, the head or part which does the work

being in the shape of one-quarter of a circle, with the edges slightly rounded to prevent cutting. This tool will break down a shoulder square. It can be used either right or left-hand, and its shape gives it a tendency to crowd towards the shoulder which will leave the stock at that point up to, or slightly larger than, the original dimensions. This tool presents decided advantages over the round tool commonly used, as this latter has a tendency to drag down the edges near where it is used, making it necessary to upset and finish the work by hand to get the body of the forging uniform throughout. When round stock is being broken down it is usually placed in a circular tool similar to a swage, which necessitates the using of a different tool for each size of stock. If a tool is used of the style shown in Fig. 47, which is made in the form of a V-block with a rounded bottom, it will accommodate several sizes of stock. Four or five such tools of different sizes will cover a large range of work.

Fig. 49 shows how the breaking down tool and the V-block should be used in the steam hammer. The V-block is placed upon the bottom

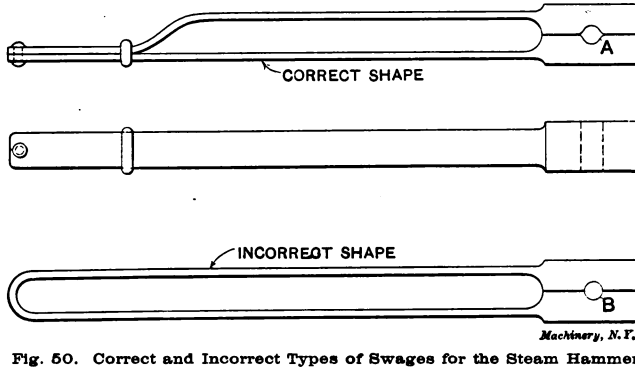


Fig. 50. Correct and Incorrect Types of Swages for the Steam Hammer

die, the work is laid in the V-block, and the breaking down tool on top of the work at the point intended for the shoulder. The tool is guided by hand until the piece has been marked all the way around. It can then be driven in, turning the piece continually, until it has reached the required depth. In drawing the shank of a forging, such as is shown in Fig. 46, it should be kept square until it has been reduced to the required size; the corners are then worked in until an octagon shape is obtained; and, finally, the corners are rounded. This procedure prevents the center being "piped."

In finishing round work, it should be done as far as possible at the steam hammer, using spring swages. Of these there are several styles. Fig. 50 shows at the top the style which is simplest and most satisfactory to use. The swages are made in two separate parts and held together by one rivet, and provided with a band to keep them in alignment without having to use a guide pin. The impression in each part should be half the depth of the diameter of the pieces the swages are intended to finish, so that it would be impossible to swage a forging under size. The edges or lips should be well backed off to pre-

vent a fin or flash being formed. If a fin or flash is formed upon a piece of work while it is being finished in swages or dies, it is liable to get worked into the forging when it is turned for the next blow of the hammer, forming what is known as a cold shut. This may not be noticed on the forging, but will show up when the work is machined; it is unsightly on machine steel pieces, and renders tool steel useless for all cutting purposes.

Swages of the style shown at the top in Fig. 50 can be made to form collars, ends for connecting-rods, blank-headed eye bolts, forgings with ball ends, and a variety of other pieces. No machine work is necessary on this kind of swage, as it can be made and finished complete in the blacksmith shop by using a dummy, or a forging made as near as possible to the dimensions of the pieces for which the swage is intended. This sample forging is used for finishing the impression, after it has been partly worked to shape, by heating the swage, and placing the dummy in it. The swage takes its impression from the dummy in the same manner as forgings take their shape from swages or dies. This method of making tools is known as typing, and can be

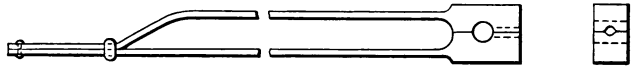


Fig. 51. Swages for Making Blank-headed Eye-Bolts

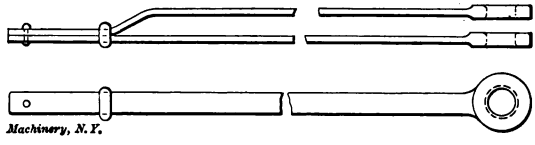


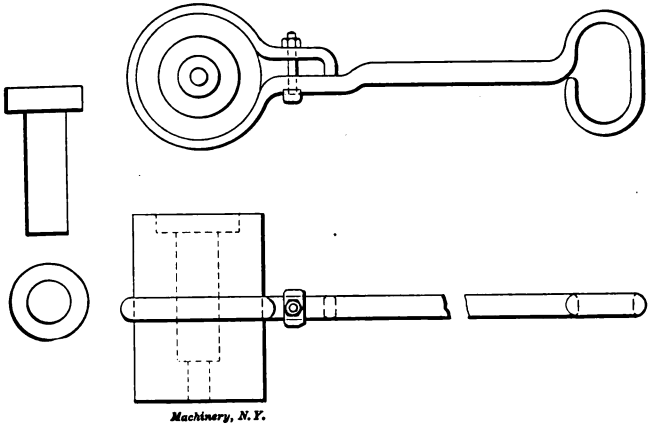
Fig. 52. Swages for Forging Hubs

employed to good advantage on a great many kinds of forgings, when the quantity to be made is such that it will justify the making of tools. All forgings made in tools as here described will be duplicates and finished in less time than would be possible by hand.

Fig. 51 shows a swage for making blank-headed eye bolts, or any forging with a circular head and a plain round shank. These are different from other swages in that they have the edges of the impression sharp where the head of the forging is formed to insure a perfect circle. A fin or flash may be worked out where the impressions meet, but it will do no harm as it can be trimmed off with a chisel. The edges of the part of the impression where the shank is formed should be rounded off, as a flash formed at that point would cause trouble in finishing with ordinary spring swages.

When forgings with hubs are to be made, ring swages, as shown in Fig. 52, should be used. All that is necessary is to select stock heavy enough to allow the ends of the hubs being finished. The work is heated, placed in the swage, given a few blows by the steam hammer, and the hub is formed, both sides being in perfect alignment. The

stock worked out at the sides can be trimmed off with a chisel. This may seem wasteful, but the time saved will more than compensate for the loss of material. For round bosses a tool similar to half the swage, Fig. 52, should be used; or a plain ring made of round stock would answer the purpose, by being placed upon the stock while it is



Figs. 53 and 54. Pin to be Forged, and Tool used for Carrying Out the Operation

hot, and struck a few blows with the steam hammer. It may be well to explain the difference between hubs and bosses; hubs project on both sides of a forging, while bosses only project on one side.

In making forgings of the style shown in Fig. 53, it is customary

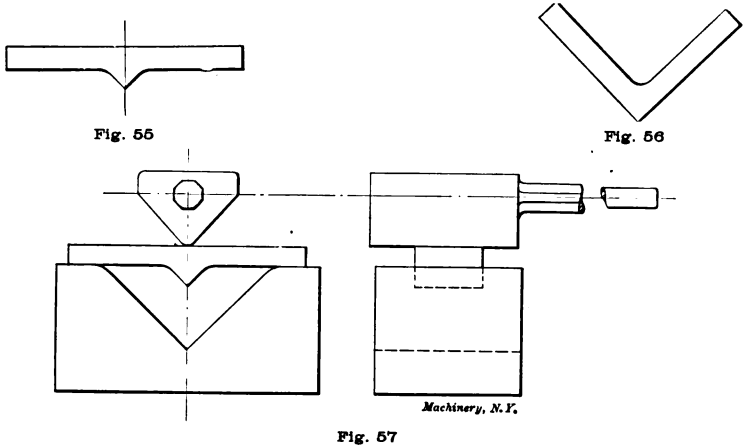


Fig. 57

Figs. 55 to 57. Forging an Angle Iron

to draw them from stock of larger diameter than the shank, and finish them in a heading tool. When a quantity has to be made, it is of advantage to use stock the proper size for the shank, cut in lengths, and to use a tool as shown in Fig. 54. This tool is bored out just deep enough for the length of the shank and counterbored to accommodate

the head. The stock should be heated on one end, placed in the tool, a few blows given by the steam hammer, and the forging is completed. A small hole should be drilled through the bottom of the tool, so that it can be turned up-side down, and the forging removed with a punch. Six forgings can be made in this way in the same time as it would take to make one, if drawing it from heavier stock.

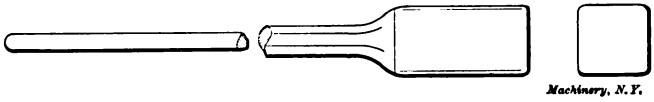


Fig. 58. Tool for Drawing Work too Short for Breaking Down under the Steam Hammer in the Usual Manner

In making angular forgings, stock of about the right size for the ends of the angles is usually selected, bent, and the corner worked back until it is square. This takes considerable time and careful working, or a cold shut will be formed inside the corner. With a steam hammer, pieces of this shape can be made with very little

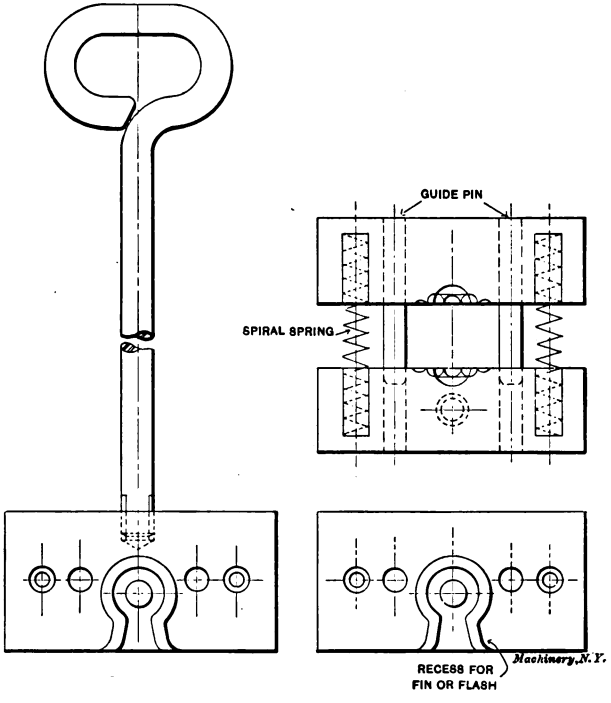


Fig. 59. Dies for Drop Forging under the Steam Hammer

trouble by using stock heavy enough to allow a solid corner being formed as shown in Fig. 55, which can be done by using a round tool to break down each side of the piece intended for the angle, drawing the ends to the required size. Then the piece is bent in a V-block with a tool made for the purpose, as shown in Fig. 57. The result will

be a piece as shown in Fig. 56. The V-block should have an included angle of 90 degrees, and be rounded at the top edges, as shown, to prevent marking the ends. The tool for bending should have the edge or corner rounded so that it will form a fillet inside the forging. Nearly any size of angle can be made with the same tools.

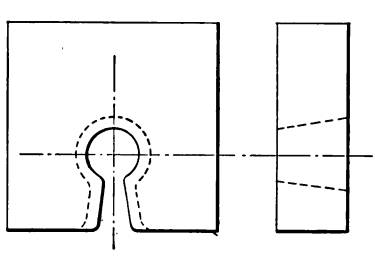


Fig. 60

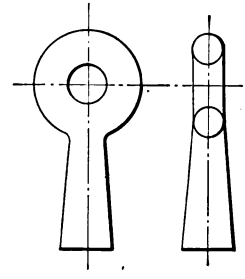


Fig. 61

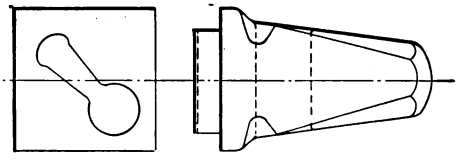


Fig. 62

Figs. 60 to 62. Trimming Die and Punch and Completed Work

A tool for drawing work which is all broken down to one side, or between shoulders or bosses, when the distance is too short to reach across the dies, is shown in Fig. 58. The head is square, and the corners rounded, each to a different radius, so that fillets of different dimensions may be formed with the same tool.

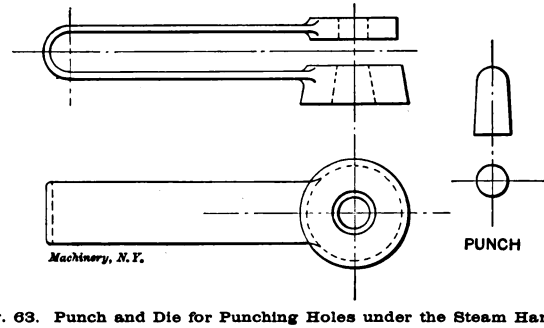
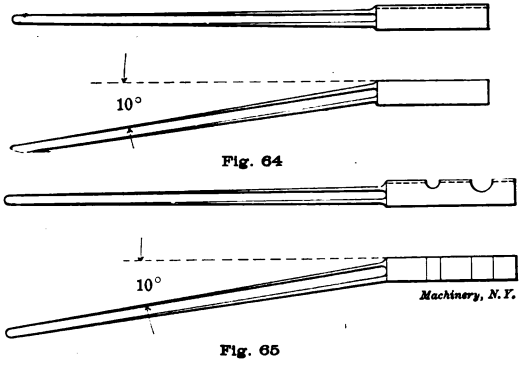


Fig. 63. Punch and Die for Punching Holes under the Steam Hammer

Small pieces can be drop forged at the steam hammer without changing the ordinary dies, by using dies as shown in Fig. 59. The impressions are sunk the same as in regular drop forging dies. The dies are kept in alignment by two guide pins, and opened by two spiral springs placed as indicated. The dies are removed from the hammer dies by means of the handle attached to the back as shown. Forg-

ings made in this style of dies are equal in every respect to regular drop forgings, with the exception that it requires more time making them. The steam hammer can be used to trim the forgings by using a trimming die and punch as shown in Figs. 60 and 62. Trimming dies of the style in Fig. 60, with open end, should be made heavy enough to prevent spreading, or breaking through at the back, as they have no supporting device of the kind used for dies in the trimming press. They also ought to be deep enough to allow of the forging dropping out of the reach of the punch when it is trimmed. Fig. 62 shows the punch, the face of which should be concaved to fit the forging it is intended to be used for. Fig. 61 shows the forging made in the dies in Fig. 59. The ends of the shanks are left heavy so that they can be finished either for eye-bolts or hooks. When made into hooks the shanks are left longer, finished in spring swages, and bent on a former made specially for that purpose. The style of dies here described can only be used for small work, and only then when the quantity is such that it will justify the expense of making the tools.

The steam hammer can be used as a punch press, when that machine



Figs. 64 and 65. Tools used Under Steam Hammer for Shearing Off Stock

is not available, by using a die and punch as shown in Fig. 63. The die is made on the same principle as spring swages, the top part acting as a guide for the punch. The lower part, or die proper, should be thick enough to allow the scrap from the hole and the punch dropping below the level of the guide, otherwise the punch would be liable to be bent or broken. Punches need never be longer than the depth of the die, and should be tapered from the face to give them clearance when being driven through the stock. This style of die and punch can be used on hot work, as for removing the stock between the jaws of wrenches, the centers of eye-bolts when being forged by hand, etc.

In shops where there are no shears the steam hammer can be used for cutting off cold stock by using tools as shown in Figs. 64 and 65. Only one tool of each kind is shown, but the tools can, of course, only be used in pairs, one below and one over the stock, so that their edges will just pass by each other, the same as the jaws of shears. Fig. 64 shows the tools used for flat stock, while Fig. 65 shows the shape of

tools for round stock. These tools are not as handy as shears, nor quite as safe, but are superior to saw or chisel in cutting up stock for forging.

In forging rings of rectangular section it is customary to use stock of about the right dimensions for the section, bend it to shape, and weld it. This is all right for small rings, or large rings with small section; but when the size exceeds 5 inches inside diameter, and the section 1¼ inch square, it is advisable to make the rings from the solid stock for several reasons, the principal of which are the saving of time, a more uniform section, and a perfectly solid forging when the ring is finished. This latter is impossible with a welded ring, except at cost and labor out of all proportion to the size of the job. To begin with, the ends of the stock must be upset to allow for waste in

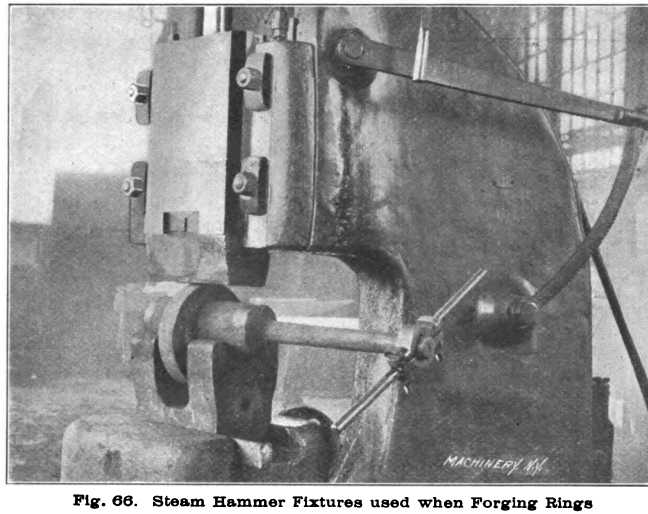


Fig. 66. Steam Hammer Fixtures used when Forging Rings

welding, and bent in the form of a circle, which distorts the shape of the material; the outside is drawn out while the inside is upset or compressed. The only part of the stock which retains its original size is the neutral line at the center of the bar. After the ring has been welded, it has to be flattened and trued up all over to get it anything like uniform. Then, there are always chances of a poor weld, which makes the finished piece useless for all practical purposes.

When rings are to be made from the solid, the first thing to be done is to find the right amount of stock to use, which can be done by consulting hand-books, or by figuring out the cubic contents of a solid piece having the same diameter and the same thickness as the ring for which it is intended, deducting the number of cubic inches equal to the hole, and allowing enough extra material for waste in forging, and for finishing in the machine shop. Cut off a piece of round stock the proper length, and upset it under the steam hammer until it is of the same thickness as the face of the ring to be forged. Punch a

hole in the center, and "drift" until it is approximately of the diameter required in the finished ring. The lower die should then be removed from the steam hammer, and a fixture of the style shown in the half-tone, Fig. 66, keyed in its place. This fixture is made in the form of a double V-block, the V's being circular in the bottom, and of an angle of about 120 degrees, allowing the use of different sizes of mandrels in drawing the rings to the required size. The ring or piece of stock with the hole punched through it is then placed between the V's, and the mandrel slipped through the hole and turned by means of the handles clamped to the shank. In turning the mandrel, the ring is turned with it, bringing a different point in line with the top die for each stroke of the hammer. This is done until the proper size has been reached, using larger mandrels as the hole increases in size. Rings up to 50 pounds can be made complete in two heats. Larger rings up to the full capacity of the steam hammer can be made by using a larger fixture in the anvil block by removing the chair for the lower die. It is advisable to use hollow mandrels for the larger sizes to facilitate their handling. Rings made from the solid in the manner here outlined can be completed in one-third the time required for welded rings. The section is uniform throughout, and no poor welds or overheated spots show up in the machining.

If the steam or power hammer were used, as it should be, to do the heaviest and most difficult work, the art of blacksmithing would be made more attractive, and the manufacturers' profits would be increased.